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ROCKY MOUNTAIN ENVIRONMENTAL RESEARCH
QUEST FOR A FUTURE, PROBLEMS AND RESEARCH
PRIORITIES IN THE ROCKY MOUNTAIN REGION

EISENHOWER CONSORTIUM FOR WESTERN ENVIRONMENTAL
FORESTRY RESEARCH

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*Dawn over the arid West.
It's Joshua Tree, Utah,
central Nevada, Anza
Borrego, or somewhere off
it's part of the geography of
hope.*

Terry Russell
On The Loose

ACKNOWLEDGEMENTS

This project was launched to identify research needed to maintain and enhance a high quality environment in the Rocky Mountain Region for the long-term future. From its onset, Rocky Mountain Environmental Research -- Quest for a Future (RMER-Quest) was a participatory and volunteer process. We owe our deepest thanks to the participants who shared the optimism, gave the spark, their time and thought to bring this report to completion. Our thanks are also due the universities and other institutions within the Region who supported this volunteer effort. We owe our gratitude for the hours devoted by the task force leaders, the time spent guiding and reviewing by the Planning Committee and Advisory Council,* the documents written by task force members and Synthesis Workshop participants, and the energies devoted by correspondents to review our work.

Finally, thanks are due to the sponsors of this endeavor, to the Research Applied to National Needs division of the National Science Foundation,** to the U.S. Forest Service and to the Environmental Protection Agency.

John M. Neuhold, David E. Herrick,
and Duncan T. Patten
Project Directorate

*A list of all RMER-Quest participants can be found in Part IV, Appendix B.

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PART I

PART I - INTRODUCTION AND SUMMARY

The Region

The majestic Rockies are the backbone of the Rocky Mountain Region.¹ Extending from the Canadian border to Mexico, the Region is cut by three distinct geographical formations: the intermontane plateau to the west, the high plains to the east, and the Rocky Mountain range running through the core. Its physiography of rugged peaks, enclosed valleys, high elevation plateaus and deserts as well as the cultural traditions shaped by this environment differ from the rest of the Nation.

While containing one of the oldest settlements within the U.S., established by native Americans before the 1500's, it has been one of the last regions to develop. The Region has about 4.1% of the U.S. population while containing about 24.1% of the total land. The low population density and great distances between population centers influence every aspect of the development and use of the Region.

Now this Region is facing one of the highest growth rates in the Nation. The pressures come from two sources:

- an increased demand for scarce resources, particularly the energy related fuels and minerals, and food and fiber products; and
- an influx of new residents seeking the Region's amenities to raise their families, build a second home, to admire or retire, accompanied by growth in the well-established recreation and tourism industries.

Water remains one of the greatest limitations to growth in the Region. Though the area is vast, it is drained by relatively few river systems. The greater part of the water in the Region is already allocated to a host of uses including irrigation, industry, household, and recreation.

Common to all the Rocky Mountain States is the high percentage of land under federal management, 49.3% of the Region being federally owned. The U.S. Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and the Department of Defense are some of the principal land managers.

The public has recently become aware that the Rocky

Mountain Region has large energy reserves, including approximately² 1/3 of the Nation's coal, 1/10 of the associated and non-associated gas and petroleum³, over 1/2 of the oil shale⁴, over 4/5 of the uranium, most of the tar sands, and a large portion of the potential geothermal and commercial solar energy. The total regional percent of the BTU value of coal, gas, petroleum, oil shale, uranium, and tar sands is approximately 33% of the national proven or potential resources. Much of these energy reserves are on public lands; therefore, the entire public has an interest in the resources and the lands which contain them. Within the private sector investment from outside the Region in the ownership of these energy reserves as well as other regional resources such as timber, grain, cattle, sheep, recreational centers, rare metals, etc., is part of the economic history of the Region. The demand for these resources is increasing; the pressure to develop is growing, and environmental concerns are mounting.

For this reason people are questioning (1) the need to develop and (2) how to develop. However, before these questions can be answered, much information must be accumulated, analyzed, and synthesized. Some of this information already exists or is in the process of being researched and needs only to be utilized. Yet many facts about the Rocky Mountain Region, its ecosystems, and the impacts of resource use on those ecosystems are yet unknown.

Purpose and Process of RMER-Quest

Rocky Mountain Environmental Research - Quest for a Future (RMER-Quest)⁵ was formed with the purpose of identifying environmental problems and research questions in the Rocky Mountain Region. With accurate research to provide facts, wise management decisions can be made which will preserve our heritage and enhance the Region for future generations.

RMER-Quest was conceived of by two separate organizations: The Eisenhower Consortium for Western Environmental Forestry Research and the Committee on Future Environments of the Institute of Ecology. With the support of the National Science Foundation's RANN program, they agreed to work together in the Spring of 1973. The U.S. Forest Service and Environmental Protection Agency later joined NSF in sponsoring RMER-Quest.

¹The Rocky Mountain Region is defined as the eight states of Arizona, Colorado, New Mexico, Utah, Nevada, Wyoming, Idaho, and Montana, and portions of West Texas, and East Oregon.

²All figures represent the range of *estimated* reserves. These figures are valid for both the "proven, mapped, discovered" resources as well as for the "total potential" resources. Figures are calculated from amounts stated in U.S. ENERGY OUTLOOK: A Report of the National Petroleum Council's Committee on U.S. Energy Outlook, December, 1972.

³Figures include North and South Dakota.

⁴Figures provided by Los Alamos Scientific Laboratory.

⁵A detailed documentation of the RMER-Quest organization and process appears in Part IV, Appendix A of the Final Report.

The principal participants in this project included a broad spectrum of society from the Rocky Mountain Region. Included in the effort were approximately 350 individuals -- land managers from both state and federal agencies, resource users and researchers, academicians, industry representatives, and interested citizens. By far, the greater part of these were volunteers. Over the past year, they talked, debated, argued and came up with mutual concerns. Some questions were also left unresolved. These were questions raised by the extreme differences between development- and preservation-oriented philosophies. The deliberations were based on the following goals:

1. Identify and evaluate current and potential problems associated with the growing interaction of people and natural environments in the Region
2. Determine and establish priorities for the research required to provide the necessary basis for environmentally sound resource managements on public and private lands.

Task forces were formed to address several subject areas: Biological Resources, Human Needs and Responses, Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development, Timber and Forage Uses, and Water Resources and Uses. Task force leaders were asked to select an interdisciplinary and broad-based committee to determine the state-of-knowledge in each field, the gaps in knowledge, and thus the major needs to be researched. Each leader prepared a documented report of the findings. A draft of each task force report was sent for review and the review comments were incorporated where pertinent into the final reports (Part II). These task force reports provided the technical backbone for the RMER-Quest project. Although the division of labor sped the process of identifying research needs, it also

allowed gaps between subject areas to go unnoticed and permitted the segmentation of ideas. For these reasons, a "Synthesis Workshop" brought together an expanded group of individuals to:

1. Identify areas of knowledge which were not covered sufficiently or at all by the task force reports;
2. Identify the common themes among the task force reports; and
3. Identify the most important research priorities that would emerge from consideration at the workshop.

The Synthesis Workshop identified several major themes and many researchable issues beyond those presented in the task force reports. These are presented in Part III. The goal of ranking them on a priority basis was not achieved. Consequently, a method of aggregating the research issues from the task force reports, synthesis workshop report, and reviewer's comments was developed to arrive at what the participants in RMER-Quest most often stated to be the major researchable themes.^a To prepare the introduction to this report and refine these major researchable themes, a special writing session was called during late October, 1974. Participants were selected to represent each of the organizational structures of RMER-Quest while maintaining a diversity of backgrounds.

These major themes are presented in a sequential discussion in Part I, Section A, including references to the task force reports and synthesis workshop report where in-depth project level information on each theme can be found. Examples from these reports follow each theme under "Example Recommendations". These examples were selected for illustration only and do not have any unusual significance relative to the overall thrust of the project. The high priority research projects from each of the eight task force reports follow the major researchable themes.

^aThe content analysis method used is described in Appendix A under the section "Development of Summary Chapter".

A. MAJOR RESEARCH THEMES

REGIONAL ENVIRONMENTAL MANAGEMENT STRATEGIES

IMPROVING DECISION-MAKING PROCESSES
AND STRUCTURES.....
: institutional arrangements :
.....

The control of solutions for the environmental* problems of the Rocky Mountain Region is not directly in the hands of the citizens or researchers, but lies with regional, federal, state, and local decision makers. The level at which resource management decisions are made should be structured so that concern for the short- and long-term environmental problems of the Region are given consideration.

Many of the environmental problems within the Rocky Mountains are regional or subregional in nature and resources are not limited to a specific political region. It is imperative that the management or decision-making groups be structured to allow communication and cooperation among and within states. Management institutions should be analyzed to determine whether their interstate arrangements are structured so as to enable problem solving and decision making on a regional basis. New interstate institutions or new regional cooperative management schemes should be developed and tested.

Theme: Analyze existing institutional arrangements in the Region to determine if they adequately address environmental problems. Propose and test alternatives where deficiencies are found.

(See Synthesis Report and Task Force Reports on Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Timber and Forage Uses.)

Example Recommendations and Questions:

Would decentralized agencies be more effective in environmental management than the larger centralized state or federal agencies operating at present? (Synthesis Workshop Report, II-20 (#10))

Investigate the possible role of the Federal Regional Council as coordinator of federal agency resource development policy and projects within the Region. (Institutional Arrangements, II-C-7 (3.2.2 #3))

Examine and perhaps challenge the boundaries of Federal Regional organizations such as Environmental Protection Agency, United States Forest Service, Park Service, etc. for dealing with regional problems. (Mineral and Energy Resources, II-D-30 (#45c))

Research the benefits and effects of existing regional coalitions including permanent organizations such as the Rocky Mountain Center on the Environment, Federal Regional Councils, Federation of Rocky Mountain States and The Institute of Ecology's Committee on Future Environments; and ad hoc groups such as the Environmental Advisory Council, Oil Shale Assessment Team, etc. (Synthesis Workshop Report, III-19, Inventory #2)

.....
: future options :
.....

Aside from the structure of intraregional management, the processes that now decide or influence decision making should be examined because environmental decisions made today set the options for the future. Important in the early stage of land use planning is the written documentation of future options and their differing impacts. (Legislation specifically designed to encourage this type of planning include the National Environmental Policy Act (NEPA), the Water Pollution Control Act, and proposed land use legislation.) The originators of NEPA intended it to affect agency planning processes. Instead, so far the emphasis has been on preparing statements which meet the act's procedural requirements rather than on changing the process of formulating policy to ensure that environmental factors are considered at an early stage. The preparation of impact statements on programs such as leasing of federal lands for mining or issuing grazing permits might be a step toward improved agency planning.

Theme: Develop procedures to identify the future options of regional land use and the different impacts of those options on the environment.

(See Synthesis Workshop Report and Task Force Reports on Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development)

Example Recommendations and Questions:

Project the trade-offs which must result from competitive uses: urban, agricultural, mining processing and manufacturing needs for limited water and land resources. (Mineral and Energy Resources, II-D-27 (#26))

*Environment is used in this summary to mean those factors that are part of all natural, biological, physical, social, economic, and political systems that interact with humans.

Determine the environmental consequences of setting aside the richest coal/timber, etc., areas for maximum use and setting aside all other marginal resource areas for non-use. (Synthesis Workshop Report, III-11, Response to Imposed Change #3)

What recreational, social and other "quality of life" opportunities are lost to the public by committing resources to second-home development; who pays those social costs and how might such costs be minimized. . . (Rural Residential Development, II-F-15 (#2.1a))

Conduct case studies of past experience where public participation has been effective or ineffective in terms of its influence on the final product. (Water Resources and Uses, II-H-31, #4)

Develop information systems and an analytical capability which facilitates informed citizen participation in management decisions. (Institutional Arrangements, II-C-6 (2.4 #2))

.....
: improve communication :
.....

.....
: decision points - public participation :
.....

If we can identify the options, it is imperative to know the points along the decision-making process which focus on these options and at what stages potential future options are effectively foreclosed. In order to determine these decision points, one might conduct an analysis of private investment related to alternative land and resource uses, and the relation of such to state and federal government through income, corporate, and property taxation. Determination of these decision points should allow close examination of all stages of the process and identification of the information needed for environmentally sound decisions. Irreversible decisions are sometimes made--or the opportunity to make them lost--without many people even being aware a decision was made. Clarifying how decisions are made and how they may be influenced will particularly help citizens in presenting their views at points where they can play an effective role in long range planning.

Theme: *Identify the critical decision points affecting future options in state level land use planning.*

(See Synthesis Workshop Report and Task Force Reports on Human Needs and Responses, Mineral and Energy Resources, Recreation and Tourism, and Water Resources and Uses)

Example Recommendations and Questions:

Inventory and categorize public and private entities currently influential (passively or actively) in policy making relative to resource/environmental issues. (Mineral and Energy Resources, II-D-30 (#44))

Determine how formal resource allocation decision processes are influenced by informal events and pressures. (Recreation and Tourism, II-E-8 (#13))

Although the Rocky Mountain Region has a sense of unity, it is so vast and the diversity of institutions and people are so varied that optimum communication throughout the Region does not exist. Research findings are now often not applied, and research needs perceived by decision makers not pursued. Apart from the vast space between communities, there are many reasons for this. Institutional and budgetary arrangements may limit contacts between researchers and decision makers. Researchers are rewarded for reporting results to peers. The researchers work with a longer time horizon than the administrators who must act on a day-to-day basis. Useful results are defined by different criteria and reported in different terminology in each discipline.

Concern for improvement of communication should not be limited to a better flow of ideas between decision makers, citizens, and researchers but should also include education of the citizens, through formal schooling, seminars, symposia, etc. At many of the meetings of RMER-Quest, environmental education came to the forefront. Although there are obvious needs for research in the area of environmental education, it is thought that the recently passed Environmental Education Act will encourage sufficient research into and surveys of regional environmental education, so that it is not mentioned here as a highly significant area for research.

Theme: *Develop new methods and institutional arrangements to improve communication between and among decision makers, citizens, and researchers.*

(See Synthesis Workshop Report and Task Force Reports on Human Needs and Responses, Institutional Arrangements, Recreation and Tourism, and Timber and Forage Resources.)

Example Recommendations and Questions:

Identify the possibility of funding researchers to spend time with administrators and funding administrators to become members of research teams. (Recreation and Tourism, II-E-11 (D); II-E-12 (E))

Develop a "hotline" for research in progress in the Region to enable researchers and research sponsors to get technical reports of work in progress or planned, in order to improve research which is in the planning state, avoid redundancy, and help researchers build on each other's work. (Synthesis Workshop Report, III-23, Directing Change #1)

Develop institutional arrangements which will increase the rate of technology transfer from an academic setting to the field and the rate of management problem recognition from the field to the university and research centers. (Institutional Arrangements, II-C-10 (3.4.2))

How can information be delivered to local decision makers so that it is most comprehensible? (Recreation and Tourism, II-E-6 (C,H))

Are national environmental laws and standards compatible with regional bio-physical characteristics? (Synthesis Workshop Report, III-21, Inventory #1)

Design scenarios which assess environmental impacts of alternative legal interpretations of the non-degradation proviso of the Clean Air Act. (Synthesis Workshop Report, III-21, Directing Change #1)

If speculative value of land is decreased, does this require payment of just compensation? (Mineral and Energy Resources, II-D-25 (#18c))

Determine the legal constraints on water reuse, recycling and water reclamation of municipal and industrial wastewater. (Water Resources and Uses, II-H-35 (#11))

regulatory constraints

Decision-making processes are controlled through the structure of the management groups as well as by the legal constraints established through legislation. It is possible that the goals of an agency or institution may be geared toward sound environmental management to permit an array of future options, only to be stymied by legal restraints. Laws are also lacking that provide incentives for environmentally sound actions. Income and property tax laws and assessment procedures may encourage urban sprawl, stimulate inappropriate cutting of private timber, or encourage large families through tax deductions. Public subsidies of air and highway transportation may deter development of mass transit systems or perpetuate the movement of freight by the least energy-efficient means. Regulatory agencies whose functions have marginal contemporary relevance may compel inefficient use of land and resource use based upon archaic premises.

Theme: Identify and analyze statutory constraints, subsidy biases, and institutional anachronisms which inhibit the sound management of land and resources in the Region, and propose viable alternatives.

(See Synthesis Workshop Report, and Task Force Reports on Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development, and Water Resources and Uses.)

Example Recommendations and Questions:

What kind of incentives exist for state legislators to support regional institutions which threaten state autonomy? (Institutional Arrangements, page II-C-8 (3.3.2 #2))

management tools

Environmentally oriented legislation and policies are not developed in a void. Mechanisms and concepts must be used or incorporated into the decision-making process. Although many management tools and techniques to improve the effectiveness of decision making already exist, some of these are outmoded relative to environmental decisions, others need reexamination, and new tools may have to be developed. Modeling as a tool has predictive capabilities and allows hypothetical manipulation of different parts of a system but should be used more effectively in the decision-making processes in the Rocky Mountain Region.

Theme: Evaluate tools and techniques for management of land resources and public use of these resources for their effectiveness and their impact on resources, resource users, and management agencies.

(See Synthesis Workshop Report and Task Force Reports on Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development, Timber and Forage Resources and Water Resources and Uses.)

Example Recommendations and Questions:

Develop predictive models of public sector behavior. (Human Needs and Responses, II-B-2 (last para.))

Can models be developed so that they are useful in many geographic areas other than where they were originally constructed? (Timber and Forage Resources, II-G-5 (iv.))

Develop analytical tools for management which account for secondary and higher order consequences of land use and resource allocation decisions. (Institutional Arrangements, II-C-5 (2.3 #1.)

Develop methodologies to measure the characteristics of biological resources such as assimilative capacity, stability, and diversity.

Biological Resources, II-A-5 (#3)

total costs and benefits

A number of tools to help measure environmental impacts are in varying stages of development or use. One of the most common of these now in use is cost-benefit analysis. However, cost-benefit analysis has not in the past accounted for environmental and social costs and benefits, matters currently referred to as externalities. Nor does the present market system include a framework within which total short- and long-range costs and benefits of using renewable and non-renewable resources of the Rocky Mountain Region can be assessed. Thus, if economic and social values conflict, they can only be reconciled by the courts or the political process.

The National Environmental Policy Act mandates the inclusion of non-market considerations, but the technical capability to implement NEPA is not well developed.

Theme: Develop the means to comprehensively evaluate and project the total costs and benefits associated with alternative uses of both renewable and nonrenewable resources.

(Synthesis Workshop Report and Task Force Reports on Human Needs, Institutional Arrangements, Mineral and Energy Resources, and Rural Residential Development.)

Example Recommendations and Questions:

What is the economic cost of various degrees of population growth? (Synthesis Workshop Report, III-22, Response to Imposed Change #3)

Under what circumstances are tax incomes from rural residential developments sufficient to cover short- and long-run costs of needed services, and under what circumstances are the financial costs of services required by such developments in excess of the tax revenues generated? (Rural Residential Development, II-F-16 (2.6b))

Determine practical methods of incorporating environmental and social "externalities" into market cost/benefit analysis. (Synthesis Workshop Report, III-22, Directing Change #3)

human preferences

Market values of resources are much easier to establish than values of intangible non-marketable items. An effective means of measuring and incorporating human values and preferences into resource decisions is particularly essential. This kind of information is often more critical than information about biological or physical constraints to land managers involved in conflicts between demands for agricultural crops or timber production or recreational use. Various attempts have been made to provide ways of identifying and measuring individual and group preferences (attitudes, values, etc.) concerning matters which are not normally considered by the market system. Although such attempts have had differing degrees of success in measuring and identifying preferences, the results have not usually been in a form useful for decision-making purposes. More specifically, some attempts have been judged "theoretically unsound" and many have been conducted to serve the rather limited needs of a particular academic discipline rather than to be useful for decision making. One direction would be to develop a way of expressing preferences commensurate with the method of expressing economic factors now routinely used in resource allocation decisions.

Theme: Devise a process, including appropriate analytical techniques, which identifies important individual and group preferences and expresses them in a manner useful for decision-making purposes.

(See Synthesis Workshop Report and Task Force Reports on Human Needs and Responses, Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development and Timber and Forage Resources.)

Example Recommendations and Questions:

Identify the behavioral theories most useful for interpreting recreationists' behavior for planning and management purposes. (Recreation and Tourism, II-E-10 (G.))

Identify the values which lead to natural resource preservation and exploitation. Identify the origins of values about resources and the influential factors modifying these values. (Recreation and Tourism, III-E-14 (A))

Develop means to measure and aggregate social preferences and values within the Rocky Mountain Region (Institutional Arrangements, page II-C-4 (2.1 #4))

Identify which "regional needs" may conflict with "federal needs" . . . which diverse regional values conflict or are compatible with one another. (Synthesis Workshop Report, III-5, Inventory # 1c)

DEVELOPMENT OF INFORMATION

All decisions should be based on as much valid information as is available. Unfortunately the amount of environmental data that is available to decision makers in the Rocky Mountain Region is spotty at best. Local data often cannot be applied elsewhere. The decision maker usually asks for information on a "crisis" basis, using out-of-date existing data while waiting for the development of new facts. There are many areas in which more facts need to be obtained to provide the decision makers in the Rocky Mountain Region with up-to-date data on a continuing basis in order that they understand the complexity of the environment. These can be presented in two basic areas.

1. Social values and human needs.
2. Resource use impacts and ecological principals and constraints.

These two areas are not mutually exclusive. Obviously, many of the problems dealing with resources tie directly into human needs and ecosystem processes.

SOCIAL VALUES AND HUMAN NEEDS

lifestyle impacts

There is a wide spectrum of established and emerging lifestyles in the Rocky Mountain Region. Each lifestyle has different energy and material requirements, the fulfillment of which have varying impacts on the environment. Lifestyles which promote the conservation and efficient use of resources will reduce the pressures on the Region's resources. An understanding of the impacts of lifestyles on the resources will provide information by which an individual can select environmentally sound behavior. The supply of resources, on the other hand, influences the individual's demand for goods. At certain points, the demand may be decreased sufficiently to change or limit an individual's lifestyle. The limitation of lifestyle selection will have long-range impacts on social adaptability. Such information would be useful for long-range planning. How the residents view the Region and use its resources in relation to the rest of the country must be understood.

Theme: Evaluate the impact of various lifestyles on resource use.

(See Synthesis Workshop Report and Task Force Report on Rural Residential Development)

Example Recommendations and Questions:

For different lifestyles, what are the material and energy requirements, income requirements, work and leisure time available, and physiological consequences (mortality, mental health and illness)? (Synthesis Workshop Report, III-5, Inventory # 5a)

Given a quantity of resources, what are the present personal priority uses? How may we create personal standards for resource uses? Can these be met on a voluntary basis? (Synthesis Workshop Report, III-5, Inventory #3b)

Assess the social impacts of "new towns" and other rural residential developments on lifestyles, psychological, and social needs of indigenous and immigrant populations, including impacts on nearby ethnic communities and long-time area residents. (Rural Residential Development, II-F-15 (1.5b))

Determine new ways of developing second-home communities, "new towns", and modes of living that are less wasteful of resources (Rural Residential Development, II-F-13 (Col. 1 #8))

resource demands

The Rocky Mountain Region is a major resource center. The location and amounts of the resources are relatively well known, but there is limited information about what happens when the resources are used or altered. Demand for these resources, particularly its energy related resources, arise largely outside the Region. The Region, being small in terms of economic and political power, has very little control over such demands. In contrast, the conditions under which demands are fulfilled can be controlled. Gaining a more precise ability to estimate such demands and designing controls on resources from exploration to use would aid in comprehensive environmental planning.

Theme: Investigate constraints and influences on the patterns and trends of demand for the Region's resources. (See Synthesis Workshop Report and Task Force Reports on Institutional Arrangements, Recreation and Tourism, Rural Residential Development and Timber and Forage Resources.)

Example Recommendations and Questions:

How will the future demand for second homes be affected by: a) the conversion of second homes into first homes; b) technological innovation which provides city amenities to outlying areas; c) efforts to make urban areas more attractive and livable; d) the present and growing concern over the energy crisis; and e) water availability and water resource conflicts? (Rural Residential Development II-F-15 (1.6))

To what degree will increased demand for these renewable energy resources (such as solar, tidal, organic matter, wind, etc.) affect foreign trade and alternative uses of land on which fossil fuels are presently mined? (Synthesis Workshop Report, III-11, Directing Change # 1a)

How do cultural changes influence demands on timber and forage producing lands? To what degree are various demands substitutable? (Timber and Forage Resources, II-C-4 (viii & ix))

Evaluate the social and environmental consequences of alternative technological development policies. (Institutional Arrangements, II-C-9 (3.3.3a))

development impacts

Varying demands and specific development will make changes in the people, their perceptions and their environment. What will be the net effect on the Rocky Mountain Region?

Studies of overnight boom developments, both historical and current, can make explicit the unforeseen and unwanted consequences that now occur in the absence of comprehensive advance planning and adequate programs. Sudden discontinuities and shifts in the patterns of growth and development occasioned by changes in resource use and land conversion bring about new problems which existing institutions and programs may not be equipped to handle. Development, which might otherwise be desirable, may become undesirable because of an excessive rate of change exceeding the capacity to assimilate that change.

Theme: *Develop an ability to predict the impacts on ecosystems within the Rocky Mountain Region resulting from massive, sudden industrialization, urbanization, and development in sparsely populated rural areas.* (See Synthesis Workshop Report and Task Force Reports on Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, and Rural Residential Development)

Example Recommendations and Questions:

What will be the impacts of immigrating populations on existing communities? What would be the impact on the Region if the growth rate reached zero and immigration stopped? (Synthesis Workshop Report, III-6, Response to Imposed Change #'s 2b & d)

What are the spillover effects of vacation homes and "new town" developments upon the surrounding environment? (Rural Residential Development, II-F-13 (Col. 1 #2))

What will be the costs to rural counties to provide urban services to an expanding population? (Institutional Arrangements, II-C-7 (3.2.1 #1))

How can the costs of "boom and bust" development be redistributed to those who will benefit directly from rapid industrial development of rural areas? (Institutional Arrangements, II-C-7 (3.2.1 #2))

RESOURCE USE IMPACTS AND ECOLOGICAL PRINCIPALS AND CONSTRAINTS

limiting factors

How limiting are the resources on the Region as well as on the country? There are certain resources such as water, energy, unique ecosystems, fertile cropland, or minerals, which in the near future may become sufficiently scarce as to prohibit their abundant use and which may actually prove limiting to development and human population growth. The level of resource use for a given duration at which they will become limiting is necessary to environmental decision making.

Theme: *Identify and predict, under alternative patterns and trends of resource use, which resources will become limiting factors for either further development or sustaining the existing population and economy in the Region.* (See Synthesis Workshop Report and Task Force Reports on the Biological Resources and Timber and Forage Resources)

Example Recommendations and Questions:

Identify critical regional resources and determine their distribution, uses, possible substitutes, and the impacts caused by varying degrees of exploitation. (Synthesis Workshop Report, III-F, Inventory #5)

What resource constraints will impose the earliest limitations on resource development and environmental quality in the Rocky Mountain Region? (Synthesis Workshop Report, III-F, Inventory # 5a)

Identify endangered and rare plants and animals within the Rocky Mountain Region. (See Synthesis Workshop Report, III-9, Inventory # 4)

What population characteristics determine the response of populations to impacts? How can these characteristics be used to predict whether or not a species is endangered? (Timber and Forage Resources, II-G, 6 (vi))

..... ecosystem analysis

Basic to all these studies and our understanding of the Region is knowledge about the ecosystems within the Region. The Rocky Mountain Region includes many diverse systems, some of which have been relatively thoroughly studied, such as the timber-producing forest, and mountain rangeland, and other less studied ecosystems including the desert and tundra systems. Established techniques for estimating the biological and physical responses within ecosystems to natural or man-made disturbances, do not, in most cases, produce effective data for making management decisions on ecosystem use. Others, such as range and forest management techniques, have provided useful data. Measurement methodology of ecosystem characteristics or processes such as assimilative capacity, productivity, diversity, stability, and micro-environmental changes must be refined and developed. These procedures and measurements should be examined with reference to improving understanding of total ecosystem response.

Theme: Improve methods of measuring the ecosystem characteristics and processes that can be used to determine the effects of man's activities on an ecosystem.
(See Synthesis Workshop Report and Task Force Reports on Biological Resources and Timber and Forage Resources)

Example Recommendations and Questions:

What are the reproduction, growth, and mortality rates of important food and fiber producing species in the Region and how are these rates controlled by environmental factors? (Timber and Forage Resources, II-G-6, #i)

What is the impact of harvesting rates on the processes which determine nutrient and carbon balance of ecosystems and subsequently on system stability? (Timber and Forage Resources, II-G-6, #ii)

Analyze the structure, function, dynamics, and behavior of ecosystem complexes, ecosystems, and various taxa. (Biological Resources, II-A-4, A)

What are the effects of natural disturbances on our biological resources, and how and at what rate do ecosystems and ecosystem complexes respond to disturbances. (Biological Resources, II-A-5)

..... carrying capacity

Specific ecological principles have been applied to simple systems. Attempts are being made currently to determine their applicability to complex ecosystems including those manipulated and inhabited by man. Carrying capacity is a powerful concept where it has been quantified, such as the allowable density of livestock on grazing land for a given range condition. However, such quantification has not been determined for the number of humans which could occupy a given land area at different levels of use. Nor has the effect of human carrying capacity on carrying capacity of other species or on ecosystem stability been determined. In addition, research is needed to assess the carrying capacity of rivers', natural ecosystem for mine tailings, municipal sewage, power plant wastes, and recreation. The assessment should lead to information on what allowable level of one use produces a predictable change in the river's carrying capacity for other uses.

Theme. Evaluate the meaning, validity, and potential application of the concept of human carrying capacity to decision making concerning regional land use.
(See Synthesis Workshop Report and Task Force Reports on Biological Resources, Recreation and Tourism, and Timber and Forage Resources)

Example Recommendations and Questions:

How can visitors be acquainted with the carrying capacities of a recreational area? (Synthesis Workshop Report, III-13, Inventory #2c)

Identify the implications, to recreationists and administrators, of management decisions which are made from a carrying capacity based decision process. (Recreation and Tourism, II-E-13, B)

Determine the applicability of the carrying capacity based decision process utilized for recreation management in wilderness to other reserved areas like national parks and wild rivers. (Recreation and Tourism, II-E-13, E)

Identify threshold values beyond which natural resource use should not proceed (e.g. establishment of recreational carrying capacities). (Biological Resources, II-A-5, #5)

.....
 : energy investments :

Present energy and mineral resources within the Region are at a high level of demand in this time of scarcity. Over the long run they may remain sufficiently scarce that a manner of analysis which provides information not reflected in economic figures to decision makers may be required.

A feasibility study of any system or process should include an analysis of the total energy and material flow. Rather than examining only the gross energy and material flow through a system, the total energy and material investment should be determined. For instance, input of gasoline into a car might be ten gallons which might power the car for two hundred miles. This figure, however, does not show the complete energy picture. With incomplete combustion and mechanical limitations, energy is lost through the exhaust, friction, etc. Energy was also used in manufacturing the automobile. When the car can no longer run, it will form an 'energy bank'; that is, energy which is stored in the body itself, and a potential energy saving available from recycling. Many materials went into the manufacturing of the automobile. Water was used as a coolant in the energy production needed for manufacturing. Steel, aluminum, copper, etc. were used in the construction of the car's body, concrete in the construction of the road. Some materials can also be salvaged for recycling.

An "energy and material costing system" should be designed into which such information could be put in a form comparable to economic data so as to permit its effective use in decision making.

REGIONAL RESEARCH STRATEGY

The above list of topics is indicative of the varied concerns and the range of options open to the Region. The selection of the specific projects funded, the manner in which the research is conducted, and the implementation of findings is of great concern to the regional community.

.....
 : research relevance :

Within the context of RMER-Quest, one question repeatedly asked was: what kinds of arrangements, institutional or otherwise, can be made to do the best research job possible so that an information base for rational decision making can be built? One can infer from

Theme: Analyze the total energy and material investment for the development, processing, distribution, and use of regional resources.

(See Synthesis Workshop Report and Task Force Reports on Mineral and Energy Resources and Rural Residential Development)

Example Recommendations and Questions:

Determine within the Region the total energy investment for various population dispersions, transportation systems, manufacturing processes and agricultural practices. What is the energy cost of living in suburban, urban, or rural America? In second homes? In recreational communities? (Synthesis Workshop Report, III-S, Inventory #7 and III-8, Inventory #1 a-d)

Determine total energy investment for the exploration, extraction, processing, distribution, and use of renewable and non-renewable energy resources. (Synthesis Workshop Report, III-8, Inventory #1e)

These research themes state information needs concerning the data base, the resource interactions, human needs, and the processes by which such information is delivered to decision makers. It is imperative that the answers to these needs be found in order to maintain a high quality Rocky Mountain environment.

this question the desire to develop a *regional research strategy*. While development of such a strategy was not a task of RMER-Quest, two research themes repeatedly suggested during the RMER-Quest process could help in evolving such a strategy.

Theme: Develop regional institutional arrangements to facilitate research identification, research continuity, inter- and multi-disciplinary research organization, research funding, and the exchange of research results and technologies.

(See Synthesis Workshop Report and Task Force Reports on Human Needs and Responses, Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development, and Timber and Forage Resources)

Example Recommendations and Questions:

Identify the characteristics of recreation researchers who refuse to become involved with recreation administrators (or vice versa). (Recreation and Tourism, II-E-12, G)

Develop within the social sciences the terminology and scientific method necessary to render their work and the products of their work comparable among the social sciences and comprehensible to physical scientists, the public and public officials. (Human Needs and Responses, II-B-i, #1)

Develop new institutional arrangements within the academic community with incentives for cross-disciplinary research. (Institutional Arrangements, II-C-6, 3.1 #1)

How can present scientists be retrained into new areas of research or into new concepts, philosophies and research approaches, and how can this training be incorporated into a program of continuing education. (Timber and Forage Resources, II-G-2, Col. 2, i)

.....
: research institutions :
.....

To meet these needs several specific institutional arrangements were suggested. Most often cited was the establishment of a Rocky Mountain Research Center. Such a center could advance the idea of a regional scientific community which would deal with state and federal governments in identifying problems, identifying people to conduct research, preparing research projects, and enlisting support of governors, legislators, and others in soliciting funds for research. Other specific actions might be the development of a Rocky Mountain Research Clearinghouse which would function to collect and distribute completed

research findings and serve as a hot line to provide a listing of subjects of on-going research, and the development of a Rocky Mountain Research Forum to bring small groups of concerned and knowledgeable individuals together to identify researchable problems and exchange research findings.

Theme: Evaluate existing and possible new regional research institutions to determine their effectiveness in facilitating regionally oriented environmental research. (See Synthesis Workshop Report and Task Force Reports on Human Needs and Responses, Institutional Arrangements, Mineral and Energy Resources, Recreation and Tourism, and Timber and Forage Resources)

Example Recommendations and Questions:

What are the implications of research oriented to national problems? Explore the concept of funding projects whose scope is on small sub-regional components which in the aggregate may have a national impact. (Synthesis Workshop Report, III-18, Response to Imposed Change, #'s 1 and 1a)

How can the selection of particular research efforts be guided to improve the chances of the research being relevant to solution of land management problems? (Timber and Forage Resources, II-G-2, Col. 1, ii)

How can educational institutions be restructured to provide a more diverse "scientific reward system" than one based on publication activity? (Synthesis Workshop Report, III-20, Directing Change, #8)

How can ad hoc teams be directed and stimulated toward early production of significant results. (Timber and Forage Resources, II-G-2, Col. 2, iii)

B. TASK FORCE RESEARCH PRIORITIES

The Task Force Reports provided the technical backbone for RMER-Quest. The preceding recommendations precipitated out of these reports as well as the Synthesis Workshop Report and Reviewers' Comments.

Each of the Task Force Reports directed attention to a specific subject. Six of them focused on types of resource use: Biological Resources, Mineral and Energy Resources, Recreation and Tourism, Rural Residential Development, Timber and Forage Uses, and Water Resources and Uses. The other two looked at: Human Needs and Responses, and Institutional Arrangements. The subject matter focus of the Task Force Reports provided an in depth investigation in these respective fields. Thus the reports merit separate treatment here.

The top priority environmental research needs for the Rocky Mountain Region identified by each task force follow:

Biological Resources

1. Develop standard Region-wide ecosystem classification schemes.
2. Establish a system of research natural areas in all of the major classification units and institute baseline measurements in each for future comparative purposes.
3. Develop methodologies to measure the several characteristics of the basic biological resources.
4. Quantify the biological resources of the classification units.
5. Evaluate management impacts on the biological resources of classification units.

Human Needs and Responses

1. Design techniques capable of providing more and better information upon which preferences are based.
2. Understand the means by which to prepare people (including decision makers) to better understand and analyze the information they receive.
3. Develop means to monitor and analyze people's preferences.
4. Develop means to transmit indicators of social preferences, and analyses of them, to the decision makers.
5. Design a decision process which requires, as an integral component, well-analyzed statements of social preferences presented in terms which allow the formulation of relevant trade-offs.

6. Develop the terminology and scientific method necessary to render the work of social scientists and the products of their work comparable among the social sciences and comprehensible to physical scientists, the public and public officials.
7. Develop an institution to function as an intermediary between scientific research and the public and its representatives. This institution could bridge the communications gap between, and among, the many sciences and the public decision-making processes.
8. Create incentives for social scientists to orient the bulk of their research towards the provision of relevant information on human needs and desires to the public decision-making processes.

Institutional Arrangements

1. Consider alternative methods by which information may be made available on a systematic basis to public decision-makers, groups, and the public who will be affected by public policy decisions of governmental agencies.
2. Develop citizen participation techniques that allow for the incorporation of a wider spectrum of community interests in resource allocation decision processes.
3. Develop information systems and an analytical capability which facilitates informed citizen participation in management decisions.

Mineral and Energy Resources

1. Improve or develop new methods to obtain the maximum ore recovery possible from the different types of mining methods.
2. Develop fully integrated approaches to planning mining operations which begin with understanding the natural limitation of the area and lead to solution of reclamation and land use problems which will occur after the actual ore recovery operation is finished.
3. Increase the store of knowledge generally related to reclamation of harsh arid areas characteristic of the region.
4. Develop quantitative information on the use of water by various mining operations.
5. Project the trade-offs which must result from competitive uses: urban, agricultural, mining, processing and manufacturing needs for limited water and land resources.
6. Investigate and develop positive, incentive approaches with the objective of balance between productivity and environmental quality.

7. Determine the extent to which excessive regulatory requirements issued by multiplicity of political jurisdictions inhibit the process of bringing minerals and energy to the consuming public.
8. Determine the desirability for the establishment of authoritative entities for the purpose of dealing with the policy, control, decision making, negotiation with the Federal government, etc., which deal with regions crossing state lines.
9. Develop a comprehensive and usable information retrieval system which enables the projection of basic requirements related to developments of regional resources and interacting among these developments.
10. Identify subregional areas for which reasonable well-defined boundaries can be quantified for application of various techniques of system analysis.
14. Identify the implications, to recreationists and administrators, of management decisions which are made from a carrying capacity based decision process.
15. Determine which management tools (pricing, development, etc.) are applicable to management derived from a carrying capacity based decision process.
16. Determine the applicability of various management systems to different kinds of recreational opportunities like wilderness, semi-developed areas, amusement parks and others.
17. Identify the values which lead to natural resource preservation and exploitation.
18. Identify and develop means to inventory natural resources given various publics' resource definitions.

Recreation and Tourism

1. Determine what impacts accrue to communities when recreation opportunities (private and public, highly developed and undeveloped) are provided nearby.
2. Determine how providing recreation opportunities affects the production of other commodities.
3. Determine where impacts of recreation will occur due to water shortages, fuel shortages, population location, and production of other commodities.
4. Determine what pressures tourism and recreationally based communities place on adjacent public lands and predict what pressures might emerge in the future.
5. Predict what changes are likely to occur in tourism and recreationally based communities with a changing energy supply situation.
6. Predict which communities will survive, which can be made to survive, and which are likely to be lost with a changing energy supply situation.
7. Determine what trade-offs exist between recreation and other uses of land. What are the benefit-cost implications of trading recreation for other land uses given a current scarcity of energy products?
8. Identify what elements or factors are necessary in a system for long term recreational planning.
9. Determine the relevant attributes of people's definitions of leisure experiences. Determine what products people want to purchase.
10. Determine the economic values of leisure experiences to participants.
11. Identify the common factors which lead to changes in recreation participation.
12. Determine the institutional arrangements which can be made to increase contacts between researchers and administrators.
13. Identify the possibility of funding researchers to spend time with administrators.

Rural Residential Development

1. In the Rocky Mountain Region, what will be the expected level of second home and "new town" development by the following years: 1980, 1990, 2020? Where will the greatest pressures for these new residential units be felt?
 - a. Inventory available scenic and recreation land;
 - b. Inventory available surface transportation;
 - c. Inventory towns in scenic areas and describe their physical, economic, and social condition;
 - d. Inventory gateway transportation facilities;
 - e. Inventory the region's urban centers along with industry, employment, and population data and projections;
 - f. Inventory available water supply and determine competing water resources uses;
 - g. Inventory available energy supply;
 - h. Review land-use plans--existing and proposed; and
 - i. Review laws affecting land use.
2. Develop more refined methods to assess the impacts of potential rural residential developments in order to determine whether an area should be developed at all--what factors preclude development of any kind?
 - a. Assess the effects of development upon land, water, air, plant and animal resources.
 - b. Develop more refined methods of analysis of all environmental impacts, including impacts upon esthetics, scenery, and open space.
3. Determine the best methods for early identification of the full potential and limitations of each individual land area for developmental purposes.
4. Review and compare all existing (and pending) legislation which has any effect on "new towns" and other rural residential development, and determine the impacts of, and gaps in, federal, state, and local regulations for such development.
 - a. What are the impacts of fragmented decision making on regulation and control of "new towns" and other rural residential development;

- b. What are the positive and negative consequences of alternative methods of controlling land use;
 - c. What are the most useful and appropriate techniques to insure protection of important recreation resources, open-space areas, and natural systems and to increase preservation for public use;
 - d. To what extent do regulatory deficiencies affect vacation or residential home supply in rural areas or accelerate second-home and/or "new town" developments in a particular region; what are the intra- and inter-state variations;
 - e. What types of land-use control would be most effective and what are the impacts associated with enforcement alternatives?
5. Develop integrated, complete, and interrelated accounts of social impacts of "new towns" and other rural residential developments which are obtained before, during, and after the development, in order to learn how the dynamics of change affect people at all critical times in the development's history. Assess the social impacts of such developments upon:
- a. the community decision-making processes;
 - b. the life styles, psychological, and social needs of indigenous and immigrant populations;
 - c. satisfactions, desires, attitudes, and behaviors of native populations, and second-home owners and residents of new rural towns.
6. What are the non-economic factors that may affect market demand within the time-periods 1980 to 2020, and which may alter existing predictive models? How will the future demand for second homes be affected by:
- a. the conversion of second homes into first homes;
 - b. technological innovation which provides city amenities to outlying areas;
 - c. efforts to make urban areas more attractive and liveable;
 - d. the present and growing concern over the energy crisis;
 - e. water availability and water resource conflicts?

Timber and Forage Uses

- 1. How can research management be improved to give a better direction in the collection and presentation of new and existing information?
- 2. Since the array of possible research questions is infinite, how can the selection of particular research efforts be guided to improve the chances of the research being relevant to solution of land management problems?
- 3. Of the total information needed for land management decisions, which is the most likely to be critical in the near future?

- 4. How can existing and new information be better brought to bear on rapidly changing and unpredictable problems?
- 5. What kinds of biological and physical research activity will provide a sound and flexible information base with which to answer the questions of the future?

Water

- 1. Improve water law-consumptive water allocation systems.
- 2. Improve methods of including sociological considerations in planning of water resource uses.
- 3. Research the actual formulation and implementation of management plans.
- 4. Improve public participation in water planning and management.
- 5. Identify means to minimize environmental and ecological impact of land management practices.
- 6. Adapt systems analysis techniques which integrate quantitative analysis with concepts of economic theory for use in watershed management decision-making process.
- 7. Develop river basin management plans compatible with regional uses and demands on a multi-state regional basis.
- 8. Conduct statistical estimations of the physics and biology of total watershed systems and the constituent processes to be included in the decision-making process.
- 9. Determine the *total* costs and benefits of stream channeling and propose alternatives.
- 10. Develop basin-wide and interbasin water resource planning.
- 11. Determine the effect of reduced stream flows on aquatic communities.
- 12. Develop methods for including ecological and environmental factors in systems analysis and modeling studies.
- 13. Evaluate the effects of water transfers on source and receiving basins.
- 24. Develop improved short- and long-term weather forecasting for natural resource management application.
- 15. Conduct a water quality field study and develop a salinity model for base water quality conditions.
- 16. Develop models of the effects of recharge on regional groundwater levels, mound formation, and dissipation using finite differences and finite elements techniques.
- 17. Determine the quantity of water and water movement in the soil and substrata under conditions of re-filling and dewatering and when, where, and in what concentrations salts will be leached to the water table under recharge due to irrigation and to artificial practices.

C. CONCLUSION

Today there is time for the future. The pace and persistence of the impacts that threaten the environments of the Region are quite real. There is no immediate foreseeable decrease in the demand for the Region's resources and amenities, nor in the settlement of its lands. That is precisely why hundreds of the Region's business, research, educational, citizen, and governmental leaders joined in this intensive effort.

What is decided about these research recommendations is not academic. To a large measure, the decisions made about these recommendations today will establish the pattern for the future of the historic Rocky Mountain Region.

The future of this Region, of its people and its environments, depends on the funding and implementation of this critically needed research.

TASK FORCE REPORTS



PART II

TASK FORCE REPORT

INTRODUCTION

At the onset of RMER-Quest it was determined by the Planning Committee that in order to produce an in-depth report concerning the environmental research needs for the Rocky Mountain Region, it would be most expedient to divide into subject areas. It was recognized that such disaggregation of the project's scope would result in some amount of unavoidable duplication, as well as omissions.* In spite of these potential weaknesses it was decided to divide into complimentary, but separable areas.

The task of identifying the specific subject areas was presented to the Advisory Council at their first meeting in September, 1973. Several suggested divisions of labor were discussed vigorously during the Advisory Council meeting, which resulted in the determination to proceed with seven task forces. Five of these were grouped along resources and uses and the last two had a different focus as follows: (1) Mineral and Energy Resources, (2) Water Resources and Uses, (3) Timber and Forage Resources, (4) Rural Residential Development, (5) Recreation and Tourism, (6) Human Needs and Responses, and (7) Institutional Arrangements. In the course of task group reviews, it became apparent that issues related to biological (eco-system) resources within the Region were receiving insufficient attention in the seven task force reports. As a consequence, an eighth task force was mandated to focus attention on this topic.

Task Force leaders were selected and given the charge to (1) determine the state of knowledge in their subject area, (2) determine what gaps in knowledge exist, and (3) identify the research needed to fill those gaps in knowledge. Each Task Force leader set about in his or her own style to develop their reports. The Task Force leaders and members proceeded with their charge on a completely voluntary

basis. Each task force was allotted \$4,500 for travel and support budgets, which was generally to cover meeting logistics, and duplicating, but not salary.

Each Task Force leader followed a similar procedure for the creation of their papers. They selected group members ranging in numbers from about seven to fifteen, representing persons with pertinent and varied academic training, persons from state and federal agencies, local decision makers, general citizens, persons involved in environmental organizations, and individuals from industry and user groups. These individuals then met together, either having been given an assignment before, during, or after this meeting. Individual's contributions ranged from providing primary and secondary resource material to developing "white papers" to recording interviews with government officials.

A brief summary of work-in-progress from each Task Force leader was requested by and presented to the Advisory Council after each Task Force had had the opportunity to meet at least once. Severe and gentle Advisory Council criticism was voiced to help steer the leaders. The draft final reports were requested on February 18, 1974. Upon receipt, the reports were sent to approximately 150 people for review. The reviewers' backgrounds were as diverse as those of the Task Force members, but none of the reviewers had contributed directly to the reports. The reviewers' comments were compiled, duplicated, and returned to the Task Force leaders, Task Force members and the Planning Committee to be incorporated into each of the final reports.

The Task Force reports provided the technical backbone for the RMER-Quest project and appear in final form in this section.

*These negative factors were overcome at a "Synthesis" Workshop designed to identify such gaps and duplications.



A. BIOLOGICAL RESOURCES

**Task Force Leaders: Lawrence K. Forcier and
James R. Gosz**



**BIOLOGICAL RESOURCES OF
REGIONAL ECOSYSTEMS**

**FINAL REPORT OF BIOLOGICAL TASK FORCE
OF RMER-QUEST**

July 3, 1974

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I. INTRODUCTION

The central task of the biological resources group of RMER-Quest was established by the project goals. These goals called for the identification and evaluation of problems associated with increased interaction of people and natural environments in the Rocky Mountain Region and for the development of research priorities to provide the necessary basis for sound land management in the next forty years. The biological resources group was particularly responsive to ideas that ecologists (1) provide information on the environmental consequences of various management alternatives; (2) contribute to maximizing future options for regional natural resource use; and (3) identify management activities which irrevocably, on a reasonable time-scale, disrupt natural systems.

Essentially, the committee addressed the question of "what basic ecological knowledge must be improved before precise, defensible, and integrated management plans can be created." Pursuit of this central question must take two major avenues, one addressing our current knowledge of ecosystem structure and function and the other addressing present and future biological constraints on management. Answering a question of the magnitude of the one proposed will in itself require a considerable research effort.

In this analysis we broadly define the basic biological resources of the Region, avoiding as much as possible the man-centered view which, by definition, we possess. We then suggest several categories of human activities under each of four other RMER-Quest Task Force titles which clearly affect the biological resources of the Region. Finally, after summarizing general categories in which management can disrupt biological resources, we have listed areas of research which we believe to be of major importance in the next forty years.

It should be noted that other reports of RMER-Quest consider social resources and human needs. We have therefore not written about the integration of social and economic systems with biological and physical systems in this report. Our approach has been strictly to address the impacts of development on the biological resources of the Region.

II. BIOLOGICAL RESOURCES

The biological resources of the Rocky Mountain Region are numerous, but the basic resource is the biological-physical system itself. Any attempt to fractionate this resource must be artificial because of the integrated nature of ecosystems. With this in mind, we have established four characteristics of biological resources that should be of prime importance in regional planning and management. These characteristics are (1) ecosystem stability, (2) ecosystem assimilative capacity, (3) biological diversity, and (4) ecosystem productivity. None of these characteristics is

independent of the others, but each of the four has been useful for subsequent analyses and each represents a somewhat different aspect of the resource.

A. Ecosystem Stability: This characteristic is internal to the ecosystem, where an ecosystem is defined as an arbitrary geographical volume of interacting biotic and non-living components and is connected to surrounding ecosystems by exchanges of water, materials and energy. We view ecosystem stability as the ability to: (1) withstand external pressure without substantial alteration or (2) rapidly recover following disturbance and return to the original or a new dynamic equilibrium. The high level of self-maintenance found in stable, natural ecosystems minimizes social investments and maximizes future options.

B. Assimilative Capacity: We view the filtering and buffering capacity of individual ecosystems in an area as an important characteristic of the biological resource. This characteristic allows the ecosystem to reduce the effects of potential harmful or disruptive influences, thus enhancing system stability. With this second characteristic, an ecosystem augments the stability mechanisms of other systems.

Natural systems act as protective systems by having nearly closed nutrient cycles and large storage capacities. Toxins and pollutants can be chelated by organic compounds or assimilated by organisms, and even noise levels can be dampened. Evapo-transpiration smoothes out the effects of storm activity by reducing fluctuations of water discharge and nutrient loss.

C. Biological Diversity: The available diverse genetic material of the Region is basic to maximizing management options. Genetic diversity within a population provides insurance for the continued existence of that population, as well as for other species directly or indirectly dependent upon it, despite environmental change. Man cannot easily comprehend or measure the potential significance of genetic diversity to species maintenance and ecosystem stability.

The diversity characteristic is also evidenced by the many species of the Region which provide a means of ecosystem self-maintenance. Several species adapted to occupy similar, though slightly different, ecological roles may provide ecosystems with greater resiliency in response to disturbance. This same diversity provides insurance that the loss of one species, or failure of that species to occupy a particular area, will not drastically alter the system. This results from other species or species combination being available to occupy the role of the missing species (e.g., several plant species may be able to occupy similar successional roles following disturbance of forest vegetation). Also, species diversity can enhance esthetic value.

At still a higher level, the diversity characteristic is evidenced by the number and pattern of different communities in the Region, or so-called mosaics of communities. Ecosystem components have evolved to respond to the frequencies and intensities of natural disturbance (e.g., fire adapted communities). The resultant impacts of disturbance, combined with abiotic variability, have created complex patterns of communities in the Region. The edges or boundaries of the pattern units are thought to provide suitable habitat for a variety of species and may provide the only suitable habitat for some species. Finally, the complex of community patterns, species diversity within communities, and genetic heterogeneity within populations provide the larger ecosystem unit, in part, with the stability and assimilative capacity cited above.

D. Ecosystem Productivity: The productive capacity of regional ecosystems is clearly a valuable characteristic to society. It is also basic to maintaining the biological diversity assimilative capacity, and stability of ecosystems. Ecosystem productivity is typically considered dichotomously as primary production and secondary production. Net primary production is the weight increment of autotrophs, primarily green plants. It represents that portion of the plant community metabolism which creates organic material which can be consumed by other biota. Some of this primary production or its by-products (e.g., allelochemicals) can be critical in dictating the behavior or existence of other species or the producing species itself. Particularly in terrestrial ecosystems, the portion of unconsumed material which becomes litter (detritus) is essential to the further development of the productive capacity of those systems.

Net secondary production generally refers to the weight increment of organisms other than autotrophs. This production is essential for the maintenance of adequate populations which, for example, break down organic materials, sustain other organisms, contribute to the development of soil profiles, and inhibit the buildup of pathogenic populations.

III. INTERACTIONS BETWEEN BIOLOGICAL RESOURCES AND RESOURCES REPRESENTED BY SEVERAL OTHER TASK FORCE GROUPS

The development and use of resources discussed by other task force groups clearly affect the biological resources of an area. We have identified four of these resource groups which we feel interact most significantly. Provided below are several examples of the many activities within each group which can have an effect, either beneficial or adverse, on the biological characteristics of the Region.

A. Recreation

1. The soil compaction and disruption associated with recreational development and use (trails, campgrounds, off-road vehicles) clearly affects all cited biological characteristics (assimilative capacity, system stability, diversity, and productivity).
2. Transportation to and from the site, as well as many recreational and associated activities, result in increased pollution such as: (a) toxic foreign compounds (e.g., oil, gasoline, insecticides); (b) high concentrations of naturally occurring compounds (e.g., lead products from exhaust, nitrates from human waste); and (c) high noise levels.
3. Alteration of faunal behavioral patterns, due to transportation routes and recreational loads, can result in decreased habitat utilization and secondary productivity, causing major alteration in animal community composition.
4. Manipulation of habitats and populations of game animals to increase hunting opportunities may cause changes in ecosystem complexity and interspecies relationships.
5. Direct effects of recreationists on the biota (e.g., destruction of attractive species) can also alter interspecies relationships. While one species or species group may be affected negatively, other populations may be enhanced by disturbances created by recreationists.
6. Man-caused wildland fires could subject the ecosystem to different fire intensity and frequency regimes than those it evolved under and thus could alter species and ecosystem diversity.

a. Water

1. Vegetation management to affect water use (e.g., phreatophyte control) may affect the amount, timing, and quality of water yield; erosion; plant and animal diversity; ecosystem stability; and ecosystem assimilative capacity.
2. Cloud seeding may result in such changes as increased precipitation in one area, with concomitant altered snow pack duration, and reduced precipitation in downwind areas. Altered moisture budgets and growing seasons could affect plant and animal community composition, productivity, and diversity.
3. Water used in industrial processes, power generation facilities (other than hydroelectric generators), or irrigation can reduce streamflow below levels needed to maintain aquatic ecosystems. Application of certain irrigation and agricultural technology can lead to salinity problems (e.g., saline seep in Montana).
4. Stream diversion and channelization alter the physical habitat and thus affect the aquatic community.
5. Utilization of aquatic ecosystems for waste disposal from one or many sources can alter the biological characteristics of these systems.

C. Timber and Forage

1. Road construction, road maintenance and traffic result in soil disturbances, stream diversions, air and water pollution, and disrupted wildlife behavioral patterns.
2. Timber harvesting itself results in soil disturbance, changes in the hydrologic budget, reduced assimilative capacity and alteration of wildlife habitat.
3. Forest regeneration and thinning result in soil disturbance, etc., as cited above, and potential ecosystem simplification. Tree improvement activities can reduce genetic diversity.
4. Grazing activities can result in changes in ecosystem structure, both biotic and abiotic. Grazing leads to increased competition for wildlife and potentially to decreased vegetative species diversity.
5. Fertilization leads to changes in competitive relationships among species and ecosystem productivity.
6. Herbicide and pesticide application may change all cited characteristics of the biological resources.
7. Fire control changes the frequency and intensity of fire from those under which the biotic community evolved and thus may change species and ecosystem diversity. Natural and man-influenced fire regimes may differentially affect the abiotic component of ecosystems.
8. Predator control changes interspecies relationships, particularly length and complexity of food webs, thus may alter biological resources.

D. Mineral Mining and Energy

1. Mining (strip, open pit, and in situ) and oil shale exploitation change soil profiles, water quality and yield, topography, wildlife habitat, and ecosystem productivity.
2. Exploration, road construction, and vehicle travel cause soil disturbance and changes in air and water quality.
3. Smelting, gasification, liquifaction and power generation change air and water quality with possible concomitant changes in wildlife habitat. Power transmission structures and pipe lines may be particularly important in altering this habitat and wildlife behavior.
4. Reclamation activities, including revegetation with exotic species and monocultures, change ecosystem complexity and interspecies relationships. Productivity, forage nutrient content, mineral cycling, and ecosystem stability can also change and thus necessitate adjustments on the part of the native community.

IV. COMMON CATEGORIES OF BIOLOGICAL CHANGE DUE TO NATURAL RESOURCE USE

Numerous specific activities could be listed which affect the biological resources of the Rocky Mountain Region. However, the list already presented provides insight into several categories of change wrought by natural resource use. These activities are expected to increase in scale to 1990 and, without drastic planning measures, will probably increase to 2010. Although the resource use activities are diverse, their effects on biological resources have much in common. We foresee changes in three major categories, each of which affects the four biological resource characteristics. The change categories include (1) alterations of the abiotic environment with potential reduction of the land and water base for biological resources, (2) alteration of biotic components of ecosystems, and (3) alteration of interecosystem relationships.

A. Alteration of the Abiotic Environment: Reduction of the land and water base may be direct by taking a portion of this base out of production or indirect by decreasing the primary productivity of the area. In either manner the diversity, stability, or assimilative capacity of the total system is reduced. Additionally, the effects of reducing the land and water base are dictated by the needs and behavioral traits of organisms. For example, a relatively large and useful area for preservation of the genetic heterogeneity of several populations of small and abundant mammals may be of little use for retention of a larger, rare organism such as the grizzly bear. That is, not only does the condition of a particular area affect its usefulness, but also the size of the area and its continuity with similar areas are important.

Alteration of the abiotic environment results from activities such as fertilization and soil compaction. More generally, activities which alter the abiotic environment include those which (1) pollute with toxic materials, (2) cause eutrophication with excesses of biologically critical abiotic substances (at the extreme, in the Rockies, eutrophication can directly reach toxic levels, e.g., saline seeps), (3) impoverish by reducing needed physical or chemical constituents, and (4) alter normal microclimatic regimes or the frequency and intensity of disturbance. Any and all of these activities can and probably do reduce the biological resources of the Region.

B. Alteration of the Biotic Components: Revegetation of harvested forest areas and predator control are examples of management activities that lead to biologic change or alteration of the biotic component of Rocky Mountain ecosystems. Any activity which simplifies a community, changes its evolved developmental processes, introduces new species (exotics) to it, reduces its population size, or eliminates a species from the community can affect biological resources. The effects can be direct or indirect through changes in the interrelationships of species and species groups.

C. Alteration of Interecosystem Relationships: The final category is the least obvious, but two examples hopefully will clarify this idea. First, watershed studies have indicated the important influence of terrestrial ecosystems on aquatic systems. The proportion harvested of a large forested system may reach a threshold level which leads to long-term disruption of that system and adjacent aquatic ecosystems. Alteration of the natural interaction of these ecosystems may result in reduction of the assimilative capacity of the system-complex. Second, behavioral characteristics of mobile species may necessitate that specific sets of interecosystem relationships occur for the survival of these species. This may be especially important in the Rocky Mountain Region where a number of biotic zones and biomes occur over relatively short distances. Natural disturbances which result in a mosaic of different successional stages augment Regional diversity. Activities which change the proportion of mature and immature ecosystems (e.g., fire suppression) cause changes in the amount or kind of "edges" and can affect overall diversity and the productivity of particular ecosystem components.

V. RESEARCH PRIORITIES

The highest priority research needed for maintaining and enhancing the biological resources of the Rocky Mountain Region can be considered under the umbrella of ecological zoning. The zoning process should involve: (1) the quantitative evaluation of biological resources in a zone; and (2) prediction of the changes in biological resource values due to any one management activity or combinations of activities within a zone. Besides relative changes, tolerable absolute or threshold values should be predictable; that is, ecological zoning should clearly state what activities can take place and at what level without irreparable damage to the system.

A. Multiple Use and Multidisciplinary Inventories of Biological Resources: Prior to, or at least concurrent with any research on this general topic, we should undertake a synthesis and evaluation of existing knowledge of our biological resources. This synthesis would include analysis of the structure, function, dynamics, and behavior of ecosystem complexes, ecosystems, and various taxa.

New inventory research would likely consider structural or state variables, as well as process studies. Before rational decisions can be made among management options, we must be able to ascribe value effectively and convincingly to potential management units based on their stability, assimilative capacity, biological diversity, and productivity.

B. Prediction of Biological Change Due to Disturbance: The role of modern man can generally be characterized as one of causing disturbance to ecosystems. Ecosystems of the Rocky Mountains have evolved under the influence of various natural disturbing agents. A major research priority should be the estimation and elucidation of the role of natural disturbance in ecosystem function. That is, what are the effects of disturbance on our biological resources, and how and at what rate do ecosystems and ecosystem complexes respond to disturbance?

Because of modern man's obvious effect on disturbance frequencies, intensities, and patterns, we should evaluate how and in what ways present and expected future disturbances to Rocky Mountain ecosystems are different from those under which present ecosystems evolved. What are the effects of various sizes and patterns of disturbance units and their interactions with other units in terms of our entire biological resource? Furthermore, the interrelationships of management activities must be investigated. Individual activity types and intensities may be predicted as safe in terms of their irretrievable effect, but our capacity for prediction must include that of noting potential change resulting from management activity on adjacent and even distant land units. Potential chain effects leading to unacceptable reduction of our biological resources should be investigated. Biologists must also provide managers with solid information on trade-offs among various resources. For example, practices which stimulate productivity in a particular ecosystem component may simultaneously reduce the assimilative capacity of the system but enhance genetic diversity when considered in the context of the total management milieu. Managers, as representatives of the public, cannot be expected to make fully defensible decisions concerning trade-offs among resources, regardless of their decision making sophistication, unless biologists provide them with reasonably sound predictions.

Considering the diversity of natural ecosystems in the Rocky Mountain Region and the urgency of many impact studies, it would be unwise to promote one classification scheme or analytical procedure to the exclusion of others. Biological processes can be studied in many ways. Manipulative studies, systems analysis procedures, or analysis of biotic communities along natural gradients are but few of the techniques capable of yielding valid predictions concerning biotic responses to specific disturbances. The method ultimately selected will depend on ecosystem peculiarities, time, budgetary, and personal limitations; and the kind of information needed.

C. Continuous Synthesis and Rezoning: Because social expectations change continually, planning is a continuous process. Similarly, ecological zoning must be a continuous process as better information is obtained on the resources and as new management technologies are developed. Regional biologists must develop the capability to test changing assumptions and technologies on which management is based. For example, we should be able to zone potential coal strip mining areas according to their likelihood of recovery to productive landscapes following reclamation. However, the zones established in 1975 may be inappropriate to the technologies and extent of disturbance in 1990.

D. Conclusion: The biological resources of the Rockies are many and the applied and more traditionally basic research results needed to provide managers and the public with useful predictions of the effects of management on these resources appear meager. To list priority research areas may be premature, but development of these resources continues regardless of ecologists. Considerable effort in the next forty years must be invested in continuously zoning the Rocky Mountains on an ecological basis. The ordering of research priorities in terms of funding (e.g., proportion of investment in a subject area and geographic location) must be holistically considered by regional bodies of administrators, managers, and scientists drawn from all levels.

Within the framework of this discussion of biological resources, specific subjects in urgent need of investigation are:

1. The development of standard Region-wide ecosystem classification schemes. Standardized classification allows continual synthesis of information and reinterpretation of impacts. If the classification systems are natural (vs. those designed for a specific management need) they will have long-term applicability. Rather than rezone as technologies change, we can just update the interpretation.

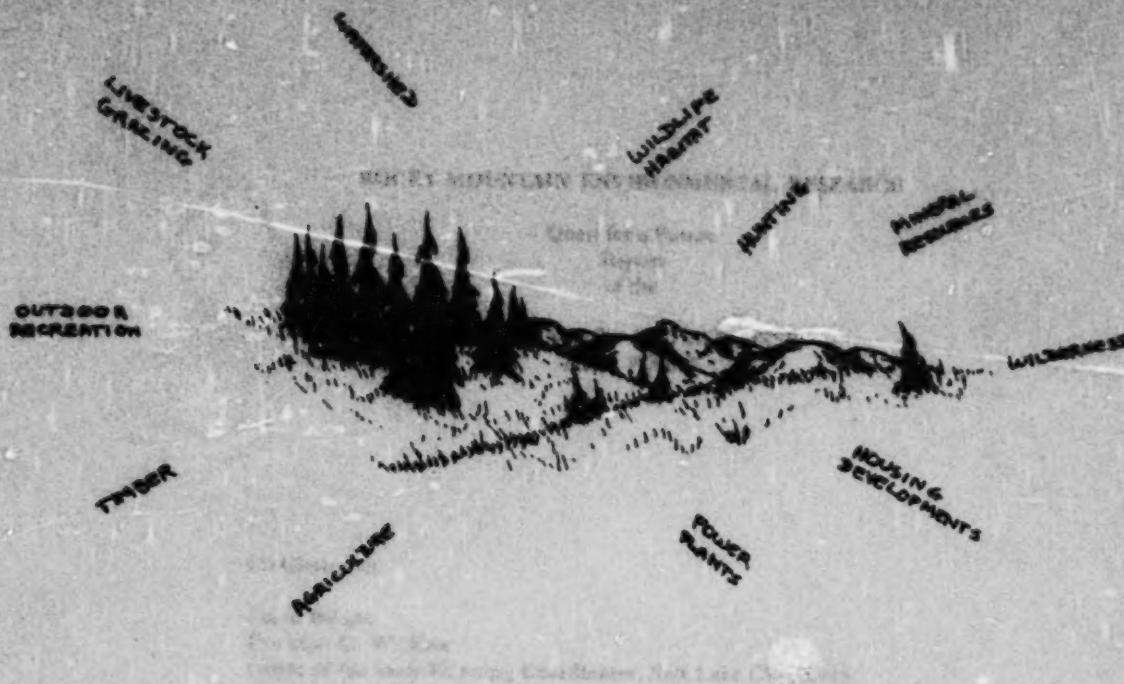
2. Concomitant with the classification effort should be the immediate establishment of a system of research natural areas in all of the major classification units and the institution of baseline measurements in each for future comparative purposes. Certain ecological islands (e.g., isolated mountains, desert springs) should be included in the natural areas system as these represent unique gene pools and natural ecological experiments.

We strongly urge the establishment of a natural area inventory staff in each state with a strong regional advisory committee. Properly standardized, local baseline studies can be useful in assessment of trends in other parts of the region. Ideally the state staffs should be constantly extracting information relevant for management as they go about their duties documenting baseline conditions.

3. The development of methodologies to measure the several characteristics of the basic biological resource. While methodologies are available to measure several aspects of productivity, few are available to measure the other characteristics. For example, how do you measure ecosystem stability and assimilative capacity? Is the basic knowledge available to thoroughly study biological diversity?

4. Quantification of the biological resources of the classification units. This effort will provide new information to the classification process itself. Part of the quantification research will ascertain the role of natural disturbance and successional development in ecosystem function.

5. Evaluation of management impacts on the biological resources of classification units. This research should establish the relative effects of various management activities, or combinations thereof, on major classification units. It should also identify threshold values beyond which natural resource use should not proceed (e.g., establishment of recreational carrying capacities). Impact research will provide additional information to the classification process.



B. HUMAN NEEDS AND RESPONSES

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ROCKY MOUNTAIN ENVIRONMENTAL RESEARCH

Quest for a Future
Report
of the

**HUMAN NEEDS AND RESPONSES
TASK FORCE**

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PREFACE

In certain respects, important changes in the requirements of the resource allocation decision process are occurring. From a process guided by, responsive to, and, in fact, virtually dependent upon, criteria and methods designed to produce an economically efficient allocation (by definition, when achieved, the optimal one), the basis of the process is changing and expanding to include many factors heretofore excluded, so that the nature of the optimal allocation may not be the same as it was before. And this is the reason for our task force's interest in the process: the way decisions are made, particularly in the public sector, reflects a growing concern for human needs and a changing point of view not only about what such needs actually are but about how they can be met through wise use of society's scarce resources.

Of course, resources are allocated on the basis of myriad decisions, large and small, public and private. The important thing is that the factors which enter the calculus upon which such decisions are based must be broad enough to encompass "human needs," however defined. In the past such factors related almost solely to the allocation criterion of economic efficiency--those determined through the normal operation of the market and expressible through the common medium of the dollar. Much criticism of this process focuses on the fact that it excludes from consideration a host of otherwise relevant matters, all of which pertain to a redefined and somewhat expanded notion of what is meant by human needs and how they are to be met. In this sense, such criticism amounts to an attack on fundamental elements of the resource allocation decision process and demands that it be reexamined. In effect, its message, among other things, can be interpreted as telling decision makers that there had better be some explicit consideration in all decisions of factors bearing on the necessity of meeting human needs. For this and other reasons which should become clear upon reading the report, the task force focused upon the decision process itself.

SUMMARY

In an economic system that relies primarily on the market to allocate scarce resources, every attempt should be made to internalize the external effects of using natural resources so that production and consumption decisions are directed by market conditions rather than by governmental agencies.* Where market conditions are not relevant, decisions should respond to the needs and desires of the people rather than to the needs and desires of governmental agencies or special interests.

Task Force Goal: To design a research program which will result in the decision-making process becoming more responsive to changing human needs and preferences.

Research Program Objectives: (1) the design of techniques capable of providing more and better information upon which preferences are based; (2) to understand the means by which to prepare people (including decision makers) to better understand and analyze the information they receive; (3) the development of means to monitor and analyze people's preferences; (4) the development of means to transmit indicators of social preferences, and analyses of them, to the decision makers; and (5) the design of a decision process which requires, as an integral component, well-analyzed statements of social preferences presented in terms which allow the formulation of relevant trade-offs.

Research Recommendations: (1) Social scientists should begin immediately to develop the terminology and scientific method necessary to render their work and the products of their work comparable among the social sciences and comprehensible to physical scientists, the public and public officials. (2) There should be devised an institution to function as an intermediary between scientific research and the public and its representatives. This institution could bridge the communications gap among and between the many sciences and the public decision-making processes. (3) Social scientists should orient the bulk of their research towards the provision of relevant information on human needs and desires to the public decision-making processes.

*It will no doubt occur to some that the market, as the principal institution through which resources are allocated, is largely responsible for present-day environmental problems. The task force members appreciate this point of view because, clearly, the market is deficient in important ways. It does not, for example, account well for matters of equity or perhaps more broadly, for the social costs and benefits of production and consumption (including the impacts of such activities on the physical environment). But task force members also share the view that the market is the best possible allocator of society's scarce resources, that intelligent planning and decision making can help overcome its deficiencies, and that a great deal of work, both theoretical and practical, remains to be done to devise a means to overcome the deficiencies of the market.

I. INTRODUCTION

A. PURPOSE, GOAL AND OBJECTIVES

1. Purpose

At its first meeting, the Advisory Council to RMER-Quest strongly asserted that development of the Region's resources should be neither promoted nor restricted solely on the basis of physical and biological attributes or limitations. This assertion derived from the notion that human needs are important and should be included along with physical and biological data and information in both the public and private decision-making processes. Consequently the Human Needs and Responses Task Force was established to address a problem succinctly stated, interestingly, in the Preliminary Report of Timber and Forage Task Group,¹ and, hopefully to the benefit of both groups, paraphrased and presented here.

It is becoming apparent that information about social constraints, requirements, and values may be of more importance to decision making than is the ever-increasing quantity of data about the physical and biological characteristics of resources; in fact, such information must be explicitly included in management considerations. Unfortunately, in matters of environmental research, human attitudes and behavior are not being systematically studied in terms of the needs of decision makers. "Until social constraints, requirements, and goals are better represented in the managerial discussion processes, it is impossible to judge which biological information is most important."² In the meantime, the lack of appropriate techniques is forcing resource managers to adopt methods which are unlikely to be theoretically sound.

Thus, the task force adopted as its general goal the following: To design a research program which will result in the decision-making processes becoming more responsive to changing human needs and preferences. When it did so, the task force fully recognized not only the complex nature of decision processes and, hence, of attempts to change them, but also the increasingly difficult conditions which frame the environment within which the processes function to attain human ends. Such conditions have been aptly described in a recent article by David M. Freeman,³ and include: (1) the lack of a single scale, or "welfare function," which would allow comparison of the diverse preferences of widely differing social groups, so that no common index exists by which the decision maker can balance the multiplicity of values, and the gains and losses to individuals

and groups, which confront him; (2) the fact that social groups are not "socially neutral"--that is, each behaves in ways calculated to maximize its standing relative to the likely results of any given decision, which means that they minimize the importance of certain information and attempt, where possible, to pass costs on to others; (3) a social system which, as a whole, is incredibly complex and, in its essentials, beyond the capabilities of any modeling effort so that many of the impacts of a given decision remain, at the time of decision, unknown; (4) a social system in which, moreover, the chain of cause and effect is difficult to perceive since events have each a multiplicity of causes so that social phenomena cannot be predicted with assurance; (5) the increasing interdependence of all things--men, resources, institutions--and the resultant large number of different individual and group preferences and valuations in modern society; (6) the decreasing portion of the "total picture" which any one group is capable of perceiving (given the growing complexity of the system); (7) the fact that increasing interdependence means that even "small" matters which formerly responded to private decisions now require political solutions; and, relatedly, (3) that small, well organized groups can exercise considerable "veto power" within the political decision-making context.

Freeman concludes his summary of the decision-making "environment" by observing that the public official must attempt to preserve, through his decisions, the widest possible range of future options. The most damaging effects of narrow decisions may be imposed upon future generations whose preferences cannot adequately be expressed today. There seems to be ample reason to focus a good deal of attention on the decision process itself.

2. Goal and Objectives

Social conflict arises from decisions on natural resource use because resulting benefits and costs are distributed unevenly among individuals and groups. This makes the achievement of high levels of public confidence difficult to attain. However, improvement is possible. While it is true that an operative welfare function is impossible, individual responses can be grouped. There are scaling techniques now developed; and interval level measurement is asserted as a means for intergroup comparison. Methods exist to control statistically for social class, political beliefs, etc.

Research designed to fulfill the following goal and derivative objectives must show ways to reduce uncertainty and conflict, and to reduce the extent of possible conflict by involving all interested parties initially and throughout the decision-making process.

¹Preliminary Report of the Timber and Forage Task Group, delivered at the RMER-Quest Advisory Committee Meeting, January 11-12, 1973, Heber City, Utah. See Appendix.

²*Ibid.*

³David M. Freeman, "Politics of Planning and the Problems of Public Confidence: A Sociology of Conflict Approach," a paper presented by the author at the October, 1972 annual meeting of the Society of American Foresters.

GOAL:

To design a research program which will result in the decision-making process becoming more responsive to changing human needs and preferences.

RESEARCH PROGRAM OBJECTIVES:

1. the design of techniques capable of providing more and better information upon which preferences are based;
2. understanding the means by which to prepare people (including decision makers) to better understand and analyze the information they receive;
3. the development of means to monitor and analyze people's preferences;
4. the development of means to transmit indicators of social preferences, and analyses of them, to the decision makers;
5. the design of a decision process which requires, as an integral component, well-analyzed statements of social preferences presented in terms which allow the formulation of relevant trade-offs.

B. THE RELATIONSHIP BETWEEN HUMAN PREFERENCES AND RESOURCE-USE DECISIONS

Expressed human preferences for goods, services, environmental quality, and so forth, are in part dependent upon human values. But concern for the relationship between preferences and the demand for resources, rather than that between values and the demand for resources, is the focus of this task force's effort because preferences can generally be recognized (at least in terms of behavior) and in many cases quantified; "values" are perhaps more complex and difficult to understand in causal terms when related to behavior. (This is not, of course, to assert that the relation of preference or attitude to behavior is a simple one, but it does seem to offer the possibility of being more manageable).

In brief, the purpose of the task force has been to identify problem areas in which the results of successful research might be useful in guiding the formulation of public policy in such a way that the future bundle of goods, services, and intangibles available in the Rocky Mountain Region is the one that most nearly matches the preferences of the regional population. The normative aspect of this matter seems to dictate concentration on the decision process itself; most particularly, as noted in the following, on those parts of it where better information, and especially quantified information, would facilitate an extension of the range of considerations which serve as the basis for resource allocation decisions.

The diagram, *Representation of the Relationship Between Human Preferences and Resource-use Decisions*, is intended to do no more than direct the reader's attention to those aspects of the decision-making process which this task force deems relevant to the nature and scope of its inquiry. As a result of its inquiry, the task force hopes to be able (1) to suggest the current state-of-the-art with regard to stated areas of concern, and (2) to suggest directions for future research efforts.

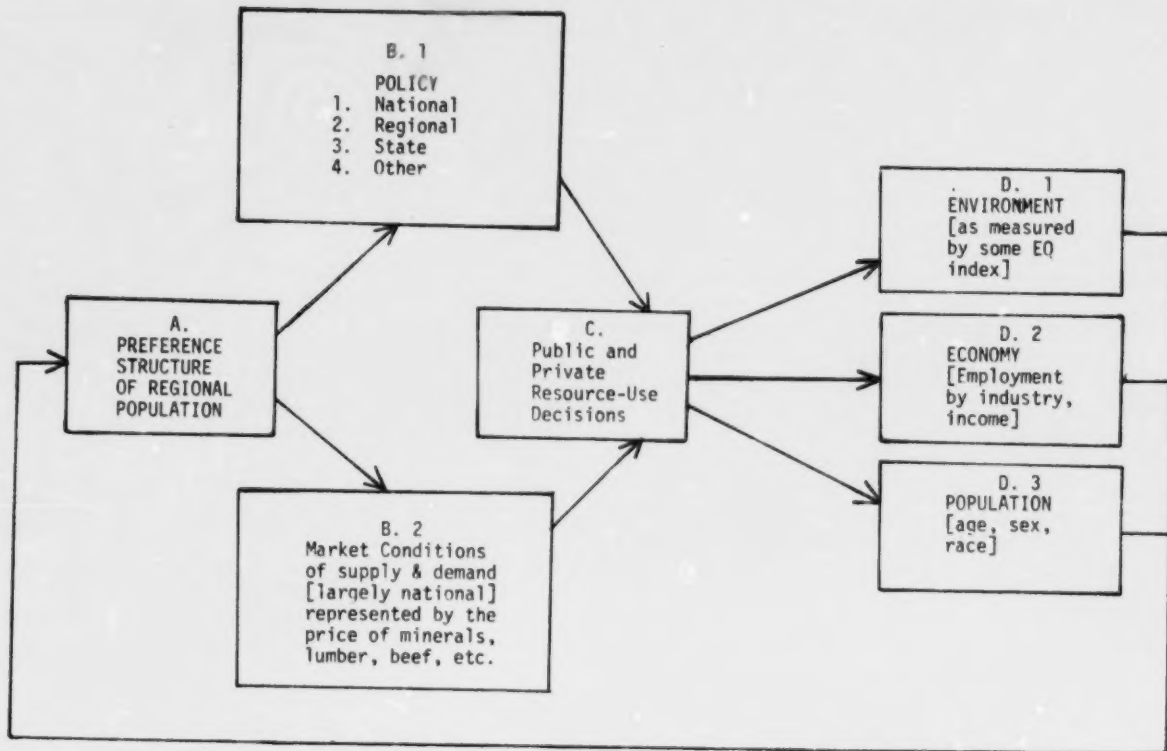
The reader will observe that public and private decisions on resource use are shown in the diagram to rely on various categories of policies (whether explicit or implicit) and on market conditions. The uses of resources which result from these decisions have impacts on the environment, the economy, and the characteristics of the population. The latter impacts seem rather straightforward and thus are not of particular concern to the task force.

The matter of the impact of decisions on the environment, however, may not be dismissed so easily. Attempts at measurement of man's impacts upon the physical environment, in order to account for such impacts before decisions are made, have not been very productive. And, as described previously, many problems confront any person who attempts to perceive and analyze changes in the environmental and social systems. The formulation of relevant objective indexes which measure such impacts on the physical environment and which help the decision maker to perceive important trade-offs is therefore a matter of the highest priority.

The task force feels it important to discuss in detail the relationship between D1, D2, and D3, and the preferences of the regional population (A). The determinants of the preferences of individuals and groups with respect to the non-market and other intangible aspects of resource-use patterns and how they can be measured, are, as the discussion to this point has indicated, the "missing" elements in many public and private resource allocation discussions. The point is, decisions on the use of natural resources create impacts which change the environment, the economy, and the population. These impacts somehow affect human preference structures. If individual perceptions of changes in the environment due to resource-use decisions are to be taken into account by the decision maker *prior* to the actual decision, then a measure must be found by which individual preferences can be aggregated and presented to the decision maker in a relevant and meaningful way. Thus, the direction of future work must be to identify these preferences and quantify them so that they can be summed, or else it must be to determine a social measurement that avoids the need to sum the individual indications of perceptions.

There is a good deal of literature on these subjects which can be summarized for presentation in this report. There are also notable deficiencies which suggest research needs. At least two areas can be mentioned at the onset. First, there is

REPRESENTATION OF THE RELATIONSHIP BETWEEN
HUMAN PREFERENCES AND RESOURCE-USE DECISIONS



a need for predictive models of behavior in the public sector. The models may deal with the behavior of agencies, political parties, individual decision makers, or other groups involved in either the formulation or application of public policy. The object is to predict the behavior of the group in terms of the objectives of the group and the constraints under which it operates.

And second, there is a concern for the way in which public preferences get communicated to decision makers. Can preferences be communicated through the ballot? Through political pressure groups? Through the market? And, equally important, are problems concerned with the way in which decision makers perceive the preferences that are revealed by the public. These subjects provide the focus for much of the material presented in the remainder of the report.

II. WHAT ARE PREFERENCES

This section of the report has two main purposes: first, to clarify what is meant by "preference" and to illustrate its importance for resource-use decisions by discussing the basis for preferences; and, second, to survey briefly the manner in which preferences are presently reflected in both the public and private decisions which daily affect resource usage. If the first topic is somewhat self-explanatory, the second is less so. Within the latter category, discussion will necessarily focus on the role of preferences in market allocation of resources, the expression of preferences by individuals and groups in settings over which the market does not hold sway, and the means by which preferences can be expressed so that a receptive decision process can function to allocate resources in accordance with them. This will provide the basis for a more thorough treatment of the decision process in Section III.

A. FACTORS INFLUENCING THE FORMATION OF HUMAN PREFERENCES*

Only rarely do people arrive at their preferences as the result of a rational evaluation of alternatives. More often, preferences are a product of influences and processes of which people may be only partially aware. These influences, which include culture, family, religion, education, socioeconomic class, place of residence, and the like, interact with and affect each other, and they have a direct effect on the formation of preferences as well. (Preferences here will mean preferences or attitudes towards life-style, for types of recreation and leisure activities, for the kind of environment desired, for family size, employment, etc.)

The largest and most pervading influence is that of culture, for the culture in which a person lives permeates every aspect of his life. There are cultural norms for work, play, child raising, family structures, interpersonal relations--everything a person does or even thinks about. Cultural norms are reflected in the preferences most persons display. This is not unexpected because adherence to norms leads to social acceptance. Included in the structure of a culture are methods the culture uses to impose its pattern on its members; these methods vary from the direct and forceful, as in the case of laws and penal practices, to the indirect and unstructured, as in the case of the social rewards which come to those who follow fashions and trends, and to those who observe "good manners."

In seeming contrast to those statements about culture is the present evidence which suggests that intracultural diversity is increasing. Greater tolerance for new ideas, better communication and education, and the ever-increasing number of choices provided by technology describe and to some extent may explain this phenomenon. And, for the same reasons, intercultural diversity is decreasing.¹ Hence, the effects of culture as a shaper of preferences may become more difficult to perceive as rigid ideas loosen and old restrictions fall away; a greater number of socially acceptable choices may result. Nevertheless, the effects of cultural factors (whether associated with regions of the country or with various sub-cultures based on age, sex, income, occupation, and so forth) will continue to be of paramount importance as influences on preferences.

The family, as the basic unit of a culture or society, has a very direct influence on the formation of preferences. It is largely the responsibility of the family to teach cultural norms to new individuals--a process called socialization. A person's preferences and attitudes tend to follow very closely those of his family. There are several reasons for this: first, parents consciously and unconsciously indoctrinate their children through the examples they set in their everyday activities; second, children have a natural tendency to imitate their parents and to retain the habits and ideas with which they have become most familiar; and third, members of a family are exposed to roughly the same physical and social environments, so that like influences are experienced.²

Schools are powerful institutions for the shaping of preferences. From kindergarten through graduate school, students learn not only facts, but attitudes, preferences and social norms as well. And, American public schools usually exhibit characteristics related to middle-class norms.³ Scarcity of resources and resultant limitations on numbers and types of programs may help account for this.

Religion historically has had a very strong influence on every aspect of human life, and although this impact at times diminishes, it remains substantial. Many of the norms of everyday behavior and the ideals which people strive for are directly related to religious teachings. The protestant ethic, for example, which has had an incalculable impact on attitudes toward work and leisure, is a product of a particular historical conjuncture of circumstances. Western man's attitude toward nature, as reflected in his preferences for kind of environment, leisure activities, and use of natural resources, etc., is not unrelated to Christianity.

Socio-economic class is correlated to some extent with pattern of preferences, although the relationship of cause and effect is not clear. People in different classes hold different types of jobs, have different amounts of education, and have somewhat different expectations from life--all of which result from (affect) preferences. Even if incomes are similar, persons from differing social strata may have markedly different tastes, buying behavior, goals, and outlooks.⁴ Psychological differences between members of the middle and lower classes have been found. A person in the middle class tends to "...be pointed to the future, is more urban in identification, has a well-structured sense of the

*In deference to economists, it must be noted that the word "preferences" is used in a more general sense than it is in economic literature. Please refer to subsection B in this section.

¹For an elementary statement of this contention, see Bernard C. Hennessy, *Public Opinion*. Belmont, California: Wadsworth Publishing Company, Inc. 1965. p. 196.

²Hennessy, *op.cit.*, p. 201

³*Ibid.*, p. 218

⁴Peirre Martineau, "Social Classes and Spending Behavior," *Dimensions of Consumer Behavior*, James U. McNeal (ed.), New York: Appleton-Century-Crofts. 1965. p. 173.

universe, has a greater sense of choicemaking, sees himself tied to national happenings..., etc.⁹ A lower-class person tends to "...be pointed to the present and past, is more rural in identification, has a vague and unclear structuring of the world, has a limited sense of choice-making, and sees the world as revolving around his family and body."¹⁰ All these characteristics either influence or are the result of preferences.

Place of residence is also correlated with preferences, but again the direction of cause and effect is uncertain. For example, people who live in rural areas may be found to prefer outdoor-oriented recreation. But do they prefer outdoor recreation because they live in a rural area, or do they choose to live in a rural area because they enjoy the outdoors? Other differences between rural and urban residents may be found.

People's preferences reflect not only these outward influences, but also their inner drives, motivations and needs. These include needs for status, approval, belonging, and self expression. The preferences expressed in the fulfillment of these needs vary extremely from one individual to another.

Finally, it should be remembered that the preference pattern of any individual or population is dynamic, not static, and is constantly being changed in ways only briefly hinted at above. What is important is the realization that the basis for preference, whether expressed by individuals, or when possible, aggregated and expressed by groups, is extraordinarily complex. Moreover (and this is the point most important in terms of resource-use decision making), mere knowledge of preferences or attitudes--difficult as that is to attain--is not sufficient as a guide to predicting behavior. The relationship is not a simple, linear one.¹¹

What is required by the decision maker, or, more generally, for an objective process for allocating resources, is a measure of group preferences. This measure should be expressed in terms which allow the most careful consideration of relevant trade-offs, and should be objective in the sense that it is independent of, or accounts for, the various factors mentioned above.¹² This important matter will be discussed in the following sections of this report.

B. HOW ARE PREFERENCES EXPRESSED AND MONITORED

THE EXPRESSION OF PREFERENCES IN MARKET ALLOCATION PROCESSES

(1) Demand for goods and services. Market allocation processes, the interaction of supply and demand, govern the prices and outputs of goods and services. *Preferences and desires, insofar as they can be satisfied by private means, are expressed in the market demands for goods and services and are statements of the various quantities purchasers are willing to buy at various prices given their purchasing power. Changes in preferences and desires result in an altered structure of market demands.* Increases in demand for a particular commodity mean that purchasers are willing to pay higher prices for given quantities of that commodity. As discussed later, this increases the profitability of production of this commodity relative to other goods and services and tends to lead to expanded supplies. On the other hand, decreases in demand will tend to have the opposite effects on prices and outputs.

Consumers as well as producers respond to a change in prices. With given incomes and preferences they will tend to buy less of a commodity as its price rises, since it becomes relatively more expensive compared to other goods, and since they will be able to buy less of all goods with fixed incomes. A fall in the price of a commodity will tend to lead to purchase of expanded quantities since consumers' real incomes rise, and they will tend to substitute this good for others as it becomes relatively cheaper.

Thus the market behavior of buyers reflects their preferences in the prices they are willing to pay or in the quantities of the various goods and services they are willing to purchase.

(2) Supply of goods and services. In satisfying the consumption desires of its population, a social system must employ some form of decision-making mechanism to mobilize and control the productive capacities of the society. Two interrelated parts of this problem can be distinguished: (1) physical capacities and (2) decision making. Important in the matter of physical capacity are

⁹Ibid., p. 172

¹⁰Ibid.

¹¹See, for example, Paul F. Secord and Carl W. Bachman, "Attitudes Organization and Behavioral Change," Chapter 3, in *Social Psychology*, New York: McGraw-Hill, 1964.

¹²Ron S. Boster and Terry C. Daniel, "Measuring Public Response to Vegetative Management," Sixteenth Annual Arizona Watershed Symposium, Proceedings of the Arizona Water Commission Report, No. 2, p. 38.

the factors of production; i.e., labor of all kinds, raw materials of all kinds (including soil surface, water, minerals, etc.) and capital equipment of all kinds (including machinery, buildings, transportation and communication systems, etc.). Also important are the physical production methods, or technologies, through which the factors of production are converted into outputs of final goods and services. But, for present purposes, the more interesting issues are related to the decision-making part of the supply problem.

In the pure form of the capitalistic system all factors of production are assumed to be owned, fee simple, by private individuals. Control over use of factors, and hence over production of goods and services, rests with the owners, the capitalists, of the relatively scarcest factors. Thus, the motive of the capitalists (i.e., the desire to maximize profits, however broadly defined) is the primary controlling element in the decision-making mechanism in the private sector.

As indicated above, changes in consumer preferences are reflected in changes in prices which consumers are willing to pay for different commodities. For any commodity, these changes in demand interact with supply (the latter reflects the cost of producing different quantities of the commodity). This interaction produces changes in realized market price and, hence, in profit. Increased price produces increased profit from production of the affected commodity and thus induces increased output of that commodity and, necessarily, decreased output of others. Further, increased output will necessitate increased costs of producing the commodity, and thus a limit is placed on the amount that output can increase. This procedure works "in reverse" to produce a decrease in the output of commodities away from which consumer preferences have shifted.

Through some form of the above process, the capitalist market decision-making mechanism produces resource allocations which are responsive to the preference structures of individuals in the society. Neo-classical economists purport to have demonstrated that, under certain unrealistically restrictive assumptions, this mechanism produces the optimal resource allocation, given the income distribution, in that it maximizes satisfaction of wants--given physical capacity constraints. More realistic assumptions produce inadequacies of resource allocation in the theory which correspond to results observable in the real world. These are generally termed "market imperfections."

The point of this discussion can now be made. If the allocative theory described above also sufficiently described the observable characteristics of the real world, the problem of relating human needs, values, and preferences to the

changing pattern of resource allocation would not be the serious one it is. However, imperfections do exist, and pervasively, in several forms: monopolistic or, more commonly, oligopolistic control of markets; governmental policies which affect the market behavior of firms and individuals, and the distribution (in theory) of both wealth and income; the so-called "externalities" resulting from the production and consumption of goods and services, and commonly observable as pollution, excessive noise, congestion, and the like; and, finally, the goods and services supplied by the government itself (which are financed by taxes and not sales revenues). In these cases, the pricing mechanism of the market does not operate to produce an optimal allocation of society's scarce resources--either in terms of economic efficiency or (in terms more relevant to the present discussion) in accordance with individual or group preferences. The need for an alternative means of ensuring the best possible allocation is indicated. It has been common to employ benefit-cost analyses in this regard.

It is clear that certain preferences are adequately expressed in the normal operations of the market. Others, however, are ignored by it. To ensure that "non-market" preferences are adequately expressed and considered in the resource-use decision-making processes, in the following sections of this report we examine current efforts to identify and measure such preferences, and recommend that research be continued in the development of a means for incorporating such information in the decision processes.

C. HOW CAN PREFERENCE MEASUREMENT BE IMPROVED

1. State of the Art

The research literature of various disciplines has developed a wide variety of different techniques for measuring environmental perceptions and preferences. Three different classes of techniques are described below.

The first class attempts to identify preference by relating usage to the physical and spatial properties of places.¹¹ They may include well-known and standard techniques such as relating usage to the number of trees or distance to lakeshore of particular campsites, or measuring average distances driven to different recreation sites. This type of technique frequently involves modeling and predictions of numbers of visitors--to national parks, for example.

A second class attempts to analyze preferences by requesting a form of numerical or categorical response from observers. Questionnaires may ask such questions as was your trip "too crowded," "just right," or "too isolated." The

¹¹Kenneth H. Craik, "Environmental Psychology," *Annual Review of Psychology*, Annual Reviews, Inc., Palo Alto, 1973, p. 404.

Gallup and Harris political polls are of this type. The data is typically presented in terms of socioeconomic class and percentage responses to each question. These techniques have widespread use, although their incorporation into the formal decision-making process has been scattered. This may be due in part to the fact that each questionnaire is usually idiosyncratic to the particular site and there are no standard techniques to compare results from one questionnaire to another or to compare one site to another.

Other questionnaires may ask people to describe the qualities of places by asking the *degree* to which a place is ugly, pretty, crowded, isolated, unique, or commonplace; or by asking the degree to which the observer likes a place; or the degree to which different places are similar.

The third class of techniques is more specialized in that it is designed to measure such perceptions as olfactory intensity, loudness of aircraft, or amount of smog in the atmosphere. These techniques are quite specialized and suited only for the specific problem at hand. It should be mentioned, however, that some of these techniques are more sensitive than any known physical or chemical analysis. The nose, for example, is the most sensitive device known for detecting the presence of certain chemicals, such as sulphur dioxide, in the atmosphere. Because of this extreme sensitivity, this type of research is critical in determining the environmental effects of odoriferous industries. Indices such as "expected number of days per year of detected odor" should be important determinants of industrial site location.

Much work has been done in attempting to measure environmental preferences, using the kinds of techniques discussed above. However, the formal use of research results in the environmental planning and decision-making activities of public agencies has been limited. If environmental preferences are to be used and balanced with more easily measured non-environmental considerations, certain problems relating to their measurement need to be resolved. At the risk of oversimplification, these problems may be divided into two broad categories: (1) problems relating to the objectivity and reliability of the techniques and methods used and the evidence produced and (2) problems relating to the relevance of the information generated to planners and decision makers.

2. The Reliability of Research Methods and Results

Problems relating to objectivity and reliability are of several types, including those concerning the nature of evidence, environmental simulation and surrogates, and semantic analysis. These will be discussed briefly in the following sections.

(a) **The nature of evidence.** Scholars in different disciplines using different techniques and methods "...display little consensus about the nature of evidence... The survey questionnaire techniques of the sociologist, the experimental work of the psychologist, the participant observations of the anthropologist, and media sources of the historian, for example, all exhibit profound differences in assumptions about what constitutes 'proof' of particular attitudes, the contexts in which they are held, and how widespread they are."¹³ Such differences do not go unnoticed by planners and decision makers, with the consequence that the reliability of evidence is questioned whether always warranted or not. This suggests the need for greater familiarity among scholars and researchers with the techniques and assumptions of all disciplines concerned with environmental perception and preference measurement, and the need for less exaggerated claims as to what individual research efforts "prove."

(b) **Environmental simulation and surrogate.** Many studies rely heavily on simulated environments or environmental surrogates, such as photographs and models, because of economy, speed, etc.¹⁴ These studies, however, are ultimately significant only insofar as they apply to reality. "Little is yet known about how responses to simulated environments differ from responses to, much less behavior in, real environments."¹⁵ Without such knowledge, of course, the reliability of much research is questionable.

(c) **Semantic Analysis.** Related to the above problem is the fact that questionnaires or interviews "...rely heavily on images of the environment filtered through language..." and can encompass "...only a fraction of all that individuals perceive."¹⁶ Moreover, "...semantic associations tend to bias responses in ways that differ from one culture to another, and indeed, from class to class and person to person."¹⁷ As a consequence, both "...the deficiencies of research relying wholly on language and the potential benefits of nonlinguistic responses and behavior..." need greater examination.¹⁸

¹³David Lowenthal, "Research in Environmental Perception and Behavior," *Environment and Behavior*, An Interdisciplinary Journal, Vol. 4, No. 3, Sept. 1972, p. 335.

¹⁴*Ibid.*, p. 336

¹⁵*Ibid.*

¹⁶*Ibid.*

¹⁷*Ibid.*

¹⁸*Ibid.*

All of these problems are significant in that they bear on the matter of *credibility* regarding current techniques and methods of measuring environmental perceptions and preferences. (The view that opinion polls and statistics can be manipulated to get any results desired is not uncommon among planners and decision makers in government). Progress in resolving the problem discussed above, and general agreement among the authorities in the field that more reliable techniques are being used for measuring environmental preferences, is a necessary condition for the more extensive use of research results in planning and decision-making processes. Such an outcome would not be guaranteed, however, because of problems relating to the *relevance* of the information generated from research. This is the second of the two broad categories of problems mentioned above.

3. The Problem of Relevance

Problems of relevance¹⁹ can be sorted into at least three areas of concern: the selection of research topic, the timing for disseminating research results, and the weighting of environmental preferences relative to non-environmental considerations.

(a) *Selection of research topics.* This problem initially involves the limitation of research to manageable yet realistic proportions. In any environment there may be a large number of stimuli to which individuals respond either positively or negatively. Research cannot, of course, hope to encompass all perceptions and preferences. Just as a silviculturist might choose to consider the size and species of trees and ignore leaf area when evaluating a potential logging area, the person attempting to measure environmental preferences must focus on certain relevant aspects of the environment.

As yet, there is little agreement about which kinds of information generated by environmental perception and preference research are of most use to planners and decision makers. It is apparent, however, that the kinds of information needed will vary with the different levels of planning and decision-making authority in government.

Two important levels may be distinguished for the purposes of this discussion: first, elected officials at the various levels of government and, second, planners and directors of the various departments and agencies of government who plan and implement programs and projects for the purpose of carrying out the mandates of elected officials or legislative bodies.

The needs of elected officials regarding environmental preferences would seem to be of a more general nature than the needs of planners and directors of government agencies. During the late 1960's, environmental preferences were channeled to elected officials in the form of lobbying efforts by various environmental interest groups. This lobbying effort was quite effective, culminating in the National Environmental Policy Act of 1969 (NEPA) which aimed at assuring detailed research and full consideration of environmental impacts in the natural resource-use decision-making processes.²⁰ However, compliance with NEPA to date has been largely procedural rather than substantive;²¹ environmental impact statements have been prepared according to established guidelines, but the substantive issue of fully balancing environmental values against economic development or other values has barely been touched.

A full balancing of such values has important implications regarding resource use; "preserving the environment" requires resources which cannot then be used elsewhere for producing goods and services. If environmental preference measurement is to be meaningful, it must be couched in terms of this trade-off relationship. "Are you willing to pay the added cost of air pollution control devices on automobiles in the interest of improved visibility and better health?" "Which is more important to you, lower timber costs which result from more intensive harvesting of national forests or the esthetic values associated with less intensively cultivated forests?" These are simple examples of the approach which should be taken in order to make environmental preference measurements more meaningful to elected officials. Furthermore, those individuals or groups being tested should be clearly identified regarding social and economic classes, income and occupational categories, etc.

¹⁹*Ibid.*, p. 338

²⁰"It was the intention of its authors that NEPA compel the thorough integration of environmental considerations into the decision-making process in every instance in which an activity of the Federal Government would significantly affect the quality of the human environment." *Environmental Quality: The Third Annual Report of the Council on Environmental Quality*, 1972, pp. 224-227, as cited in Yarrington, Hugh J. "The National Environmental Policy Act," *Environmental Reporter*, The Bureau of National Affairs, Inc., Monograph No. 17, Vol. 4, No. 35, January 4, 1974, p. 1. In his comprehensive review of the legislative history and judicial interpretation of NEPA, Mr. Yarrington states that "The Mineral King decision...eliminated any doubt that the environmental interests announced in federal statutes, such as NEPA, stand on equal footing with economic and other interests before the federal courts." p. 14.

²¹Helen M. Ingram. "Information Channels and Environmental Decision Making," *Natural Resources Journal*, Vol. 13, No. 1, January 1973, pp. 162-169.

Elected officials through the legislative process must give broad direction to resource use and the trade-offs between environmental values and economic and other values. Accordingly, the information generated from environmental preference research needs to be of the general type described above which would measure preferences in terms relevant to the formulation of trade-offs. On the other hand, the information needed by governmental agencies would tend to relate more specifically to the peculiar mission of each agency. This is a result of the fact that different agencies dealing with highways, forestry, water resources, and public housing plan and implement projects which may impinge on different and sometimes quite narrow aspects of man's environment. Accordingly, environmental perception and preference research must focus on the partial aspects of the environment affected by the particular agency. Given a decision by Congress, for example, to encourage the more intensive cultivation of national forests, research could be done to determine people's preferences regarding particular logging techniques. On esthetic grounds, do people prefer forests that have been conventionally logged (cutting mature trees), clearcut, stripcut, or logged using other techniques?¹⁴

It is also important to consider which individuals or groups of people are to be subjects of preference testing. Regarding the broad policy questions considered by legislative bodies, samples of all important social and economic elements of society should be taken. In other words, studies of individual or group preferences must explicitly recognize that the population is not homogeneous. All people who would be potentially affected by any decision on resource use should be represented in the decision-making process.

(b) The dissemination of research results. Timing is very important in the dissemination of research results. "Information is likely to have its greatest impact early in the planning process while the need for an airport, highway, dam, power plant or pipeline is still being discussed."¹⁵ At this time, decision makers are much more likely to be receptive to preference studies regarding the trade-offs between environmental values and economic development and other values than after they have publicly committed themselves on an issue. Assuming that the decision is to go ahead with the project, preference studies could still have an

impact on the specific site selection. The significant point is that environmental preference measurement is less relevant to planners and decision makers the further along a proposed project is in the planning process.

(c) Weighting of environmental preferences. Environmental impacts frequently involve qualitative factors such as esthetics that are difficult to compare to the quantitative economic impacts of governmental programs or projects. Yet NEPA and consequent CEQ guidelines require that environmental values be fully considered in decision making. Environmental preference measurements can be more relevant to decision makers to the extent that they can assist in the task of weighting the qualitative against the quantitative. Preference measurements formulated in terms of the trade-off relationship between environmental values and economic and other values would be extremely important, particularly if the measurement systems yield cardinal or interval indices rather than just ordinal or rank indices. That is, it would be much more relevant to planners and decision makers to know how much one alternative is preferred over another, than to have a statement only that one alternative is preferred.¹⁶

4. Promising Preference Measurement Techniques

Recent research literature emphasizes that there are several promising techniques now being used for measuring environmental perceptions and preference. Among these are multidimensional scaling, factor analysis, and signal detection theory. While a technical explanation of these techniques is beyond the scope of this report, some of their general characteristics and advantages might be briefly noted.

These techniques have for some time been used to analyze data collected in the social and behavioral sciences. The unifying purpose of the techniques is to discover whatever pattern or structure may otherwise lie hidden in the raw data collected and then to represent that pattern in a form which is easily interpretable by the human eye, namely as a geometrical picture or model.¹⁷

These techniques, according to some authorities in the field, are highly useful because they are quite easy to use, fairly inexpensive, and provide for easily obtained public

¹⁴For an informative account of an approach to this problem, see: Ron S. Boster and Terry C. Daniel, "Measuring Public Responses to Vegetative Management," Sixteenth Annual Arizona Watershed Symposium, proceedings of the Arizona Water Commission, Report 2, pp. 3-43.

¹⁵Ingram, *op. cit.*, p. 157

¹⁶Boster and Daniel, *op. cit.*, p. 39

¹⁷P.E. Green and F.J. Carmone, "Multidimensional Scaling and Related Techniques in Marketing Analysis," Allyn and Bacon, Inc.: Boston, 1970

involvement. In addition, they provide more than simple ordinal measurement, assure that the measurements are independent of the tastes and preferences of those conducting the research, and can display the information in easily understood, non-technical terms to planners and decision makers.¹⁴

Some work has already been done using these techniques, mainly in areas having to do with esthetics, for the purpose of providing information to such fields as landscape architecture. Little research has been done regarding preferences in the context of the trade-offs between environmental values and economic and other values. As the latter is accomplished, however, notions about preferences and judgments about intangibles can be related to more readily quantifiable economic indices in such a way as to assume an important role in the decision-making process.

III. RELATING PREFERENCES TO THE DECISION-MAKING PROCESS

The foregoing brief survey of preference measurement leads to the conclusion that it should be possible to construct objective, quantitative indexes of preferences. Moreover, a good deal of work has been and is being undertaken to relate such indexes to resource allocation decision processes. The intent of this section is, therefore, to discuss the decision-making process, to pinpoint areas in which it is deficient in considering, systematically, the preferences of individuals and groups--especially with regard to such intangibles as the esthetic aspects of alternative resource-use patterns--and to make corresponding recommendations for future research. Attention will be focused on these matters in two broad aspects: (1) the requirements of a desirable decision process, and (2) organizational changes which might help make such processes more responsive to diverse and changing preferences.

A. THE RESOURCE ALLOCATION DECISION PROCESS

The theory of demand in economics is explicitly concerned with describing the set of variables that determines individual consumption choices. Variables such as the price of the good, prices of other goods, and income have received much attention by economists. Other social scientists have investigated a broader range of determinants, e.g., class, race, or religion, as influences on preferences.

The measurement of preferences is a separate, but related topic that is at the heart of the huge cost-benefit literature. The difficulty comes in measuring benefits, since they obviously can be evaluated only in terms of people's preferences. Economists approach the problem by using market prices to reveal preferences. Benefits, therefore, may be estimated on the basis of market prices. Great ingenuity has been exercised to measure benefits in this manner. Two problems arise in the literature on this subject. The first is concerned with the way in which individuals reveal their preferences for environmental goods in the market, and the second is concerned with the kinds of market incentives that might be used to modify individual behavior in light of preferences.

As mentioned, preferences must not only be communicable to decision makers, but the decision makers must perceive the preferences revealed by the public. This matter would be simplified if a coherent and objective means were at hand for aggregating individual preferences to yield social or group preferences. It is apparent that aggregations of this sort are distinctly unlikely to yield theoretically sound results due to the impossibility of making interpersonal comparisons of, for lack of a better word, satisfaction.* This has led to research on whether it would be possible to design voting systems that would reveal social preferences.

Other, more general problems stand in the way of the communication of preferences to decision makers. Ingram, summarizing recent experience surrounding the National Environment Policy Act, cites several factors (such as the timing and context of the information, the political power of the group transmitting the information, and the like) which affect not only the expression of group preferences but also the receptivity of the decision maker.¹⁵ It is possible to speak of the preferences that people have for different outcomes. These may be measured by public attitude surveys of the Gallup-poll type; but potential differences in expressions of preferences which arise from such things as social class, type of employment, political beliefs, etc., must be constantly kept in mind. In addition to public surveys one may assess preferences by behavior. This, of course, is the ultimate measure. Behavior preferences may be expressed at the polls (voting is a behavior) or by usage patterns.

In any event, it is true that to this date benefit-cost analysis has been the most well-known means used to publicly allocate (or justify the allocation of) society's scarce

*It should be noted that although this was a problem of significance to the economists on the task force, the psychologists, sociologists and others represented there felt that techniques, such as voting, surveys and the like, are available which skirt around this particular theoretical difficulty.

¹⁴Boster and Daniel, *op. cit.*, p. 43

¹⁵Helen M. Ingram, "Information Channels and Environmental Decision Making," *op. cit.*, pp. 150-169.

resources. Many attempts have been made to generalize this procedure to include measurements of the intangible and non-market aspects of projects; employing public resources; the formulation of appropriate trade-offs relevant to assessment of potential impacts; and the inclusion, for purposes of analysis, of multiple objectives to which a project is expected to contribute.

Benefit-cost analysis derives from welfare economics. It is this branch of economics that attempts to concern itself with the welfare of the individual. In its purest form, welfare economics asserts that any public action which improves the welfare of at least one person and which decreases the welfare of none has the effect of improving the welfare of society. This is known as the Pareto criterion. However, largely because of the inability to perform interpersonal comparisons, attempts to implement policies derived from welfare economics (such as benefit-cost analysis) concentrate on the increase of aggregate national income (GNP) which could be expected to result from a particular project.²² This concentration has been justified by the premise that increases in national income tend to mitigate inequities in income distribution. The "new welfare economics" asserts that welfare is increased by actions which enable at least one person to be better off and which offer the possibility of compensating potential losers for their losses. This, too, supports the criterion of addition to GNP if it can be assumed that programs such as the graduated income tax, manpower training or welfare programs, and the like, serve to relieve the inequities of the distribution of income.

But benefit-cost analysis, despite (and possible because of) its widespread use, has created among some decision makers the "...false impression...that a simple criterion is available that can be used for legislation, court decisions, administrative regulations, and other applications of policy."²³ This is the case largely for two reasons. First, the "weights" (market prices and surrogates) used to evaluate different benefits and costs are affected by social and political circumstances as well as by economics. This failing is manifest in the use of constant technology and individual preferences when benefits and costs are computed. And second, both "external" costs and benefits (for example, such costs as pollution) are omitted from consideration in the calculus. The implications of ignoring factors of such crucial importance to the evaluation of project alternatives are, on the one hand, a vastly simplified procedure, and on the

other, a simplification achieved at considerable damage to a realistic appraisal of each alternative's expected benefits and costs.

This, of course, is common knowledge to those familiar with the benefit-cost literature, and means of overcoming these deficiencies are often proposed. A recent, pertinent example has been discussed in an article by Fisher, et. al.²⁴ In the article the authors (1) develop and rationalize a model for the allocation of natural environments between preservation and development; (2) evaluate the benefits and costs deriving from both (reminding the reader, for example, that the benefits of preservation are the opportunity costs of development) with reference to the specific case of construction of a dam in the Hell's Canyon of the Snake River; and, (3) conclude that it would not be optimal to undertake even the most profitable development there as future benefits are greater if the area is left in its natural state. This conclusion, different from a more widely circulated, conventional one, results from the authors' incorporation into the benefit-cost procedure of matters usually excluded. Though they make no attempt to assess the total benefits of preservation (which would include such difficult matters as the esthetics of the natural system), they show that consideration of the following is enough to radically alter the conventional benefit-cost presentation: (1) the differential impact of technological change, for purposes of benefit evaluation, on the preservation option as opposed to that of development; (2) the explicit inclusion of the opportunity costs of development (i.e., the benefits of preservation) in the benefit-cost procedure; (3) the changing demand for recreation and preservation due to changing preferences; and (4) use of an appropriate social discount rate.

The authors succeed in showing that the benefit-cost technique may be more flexible with regard to what is appropriately considered a benefit or a cost than many may have supposed. The fact that they have done so is the more important, however, since they did not make a deliberate attempt to develop or include in their analysis any measurable and objective indices of previously unquantifiable matters. Of course, it has been a major contention of this report that the latter are of great importance, too. Nevertheless, the important point is that research is being done, along lines suggested in this report, to improve the decision-making process; and suggestions for needed further research can be made.

²²S.V. Ciriacy-Wantrup, "The Economics of Environmental Policy," *Land Economics*, Feb., 1971, Vol. 47, No. 1
²³*Ibid.*, p. 38

²⁴Anthony C. Fisher, John V. Krutilla, and Charles J. Cicchetti, "The Economics of Environmental Preservation: A Theoretical and Empirical Analysis," *American Economic Review*, Vol. LXII, No. 4, Sept. 1972 p. 610

On the other hand, critics of benefit-cost analysis as a decision-making tool are not few. For example, Ciriacy-Wantrup¹¹ argues that benefit-cost analysis is an inappropriate tool because the assumptions required to calculate benefits and costs are so restrictive that it would be more useful to concentrate on the directions and rates of change rather than, as benefit-cost procedures do, attempt to predict magnitude of impacts. He insists that social scientists should develop a decision process that, like an insurance policy, attempts to minimize possible losses--that is, those losses incurred when decisions are avoidably irreversible. "The emphasis of this approach is on avoiding overuse rather than on achieving optimum use, on establishing base levels rather than on locating peaks, on not entering dead-end streets and on keeping direction rather than on computing the shortest distance, and on mobility and adaptability of productive factors rather than on the optimum combinations."¹² This contention is supported by the argument that social institutions are traditionally considered as constraints; in contrast they should be considered as means "...in the sense both of policy tools and of obstacles to be removed or modified."¹³ In other words, social institutions should be considered malleable, and as modifiable or replaceable when necessary to facilitate policy implementation. They are not fixed in time.

The future cannot be predicted. Economic, social, political, and psychological relationships cannot be predicted. But benefit-cost analysis implicitly predicts these by assuming them constant over time. Rather than to predict *magnitude* of change, social scientists should concentrate on directions and rates of change. Rather than predicting the future, scientists should posit alternative futures which encompass plausibility. Rather than develop THE PLAN for development of the future, scientists should develop a planning process which enables decision makers to respond to perceptions of change in the direction and rates of change. Consequently, it may be possible to increase public welfare by changing institutions and instituted policy rather than by maximizing sustained yield or rates of production. These are the general implications of Ciriacy-Wantrup's argument.

The practical implications of Ciriacy-Wantrup's suggestions are, as a means of dealing with changing human preferences, at this point unclear in their details. However, it is obvious that, at minimum, what is required by his proposal is a long-term (and continuing), multi-disciplinary study of the institutions surrounding the decision-making process. And this is certainly compatible with the recommendations contained in this report.

The inescapable fact is that decisions on the use of natural resources are and must be made. (This includes public solutions to problems which arise as a result of the "external" effects--for example, air and water pollution--of private production and consumption. In an economic system that relies primarily on the market to allocate scarce resources, every attempt should be made to internalize the external effects so that production and consumption decisions are directed by market conditions rather than by governmental agencies. Such internalization can occur when, for example, the air pollutants of a copper smelter can be recovered and sold as a by-product. Where such a happy solution is not possible, benefit-cost analysis or a suitable substitute is essential to good decision making.

Quite obviously benefit-cost analysis must be made to incorporate all benefits and costs, including, especially, the loss of options. Much remains to be done to enable the analysis to identify, quantify, weight, and sum those aspects now classified as intangible or otherwise not amenable to market decisions. Much work remains to be done to overcome the tendency to oversimplify in order to make the analysis operational. For example, it has traditionally been considered necessary to assume constant technology. This kind of restrictive assumption weakens validity and relevance.

B. POSSIBLE ORGANIZATIONAL CHANGES

For those relevant aspects of resource-use decisions which stand outside the range of a generalized benefit-cost analysis, some means of supplementing the technique is essential. And it is in this regard that the suggestions of Ciriacy-Wantrup are of particular importance. In any case, a literature exists which purports to examine the pros and cons of possible changes in organizational structure and the implications of such changes for resource management practices.

On another level of concern, the task force is aware that the ability to more effectively monitor public preferences (and it has been the position here that such is desirable) may lead, due to the complex relation between preferences and behavior, to the incorrect use of such data in specific cases. For example, a person may express a particular preference for (1) clean air in the city, (2) wide-open spaces outside the city, and (3) personal comfort when he is visiting those wide-open spaces. Thus he may express preferences (2) and (3) by purchasing a four-wheel drive pick-up camper and so compromise preference (1) because his vehicle is necessarily large, highly consumptive of energy, and air polluting. What is the decision maker to do with such information?

¹¹Ciriacy-Wantrup, *op cit.*, p. 39.

¹²*Ibid.*, p. 40

¹³*Ibid.*, p. 41

This example illustrates that expression of particular preference, or sums of individual expressions, can be misleading. Researchers note with dismay that people's behavior is frequently not consistent with their attitudes. But it is possible that inconsistencies may be more apparent than real, and that they may result from a lack of relevant options faced by those whose preferences are being reported. These difficulties suggest that it is necessary to devise an operational structure which will enable a *comprehensive* system to monitor, collate, and utilize preferences and their implications, and to transmit the relevant information to all who might make use of it. Clearly, a partial system could result in the danger of decisions based on observed particular behavior.

These points may be obvious to students of the techniques discussed in this report, but they are by no means obvious to the decision makers who must use the results of them. The problem, therefore, is partially one of communication.

Consequently, the task force feels it appropriate to recommend the establishment of some means which can function as an intermediary between government and academia. The task force recognizes that this recommendation is properly within the purview of the Institutional Arrangements Task Force. However, the efforts of this report lead to the inescapable conclusion that the problem of social research is not simply a matter of its quality or quantity, but, rather, stems in part from its isolation from the experience and requirements of public administrators, and frequently from its many practitioners. This communications gap is not clearly defined because, in fact, a great deal of research takes place within government, and, of course, many academicians are more or less involved in public administration and decision making. While this situation must be taken into account, it remains the case that a gap between research and public administration does exist. Hence, the current decision-making system is inefficient. This could be overcome, at least in part, if the results of research were more readily available to and useable by the decision makers themselves.

Means to identify, measure, and analyze social preference structures can only be developed by research of the highest academic quality. Operational methods to utilize the resulting data and information must necessarily be developed by the practitioner. Some form of intermediate institution, staffed by people "neutral" between the burdens of pure academic research and the day-to-day exigencies of public administration, can very likely bridge the gap and consequently improve the quality of government and the efficacy of research.

IV. SUMMARY OF RECOMMENDATIONS

The recommendations of the Human Needs and Responses Task Force are as follows:

1. The task force recognizes that attempts to improve the flow of information to decision makers, and thereby to improve the decision-making process itself, must of necessity be multidisciplinary in approach. To be effective in this regard, it is necessary that arbitrary barriers to interdisciplinary communication be overcome. As it is, each of the various disciplines employs a technical and esoteric terminology, directs its research efforts toward differing objectives, and operates under different criteria as to the characteristics of useful results. That these problems be overcome is a matter of the highest priority.

2. The task force accepts the idea that technical aids to decision making have limits, as yet not clearly understood, with regard to the inclusion of human preferences in resource-use decisions. It therefore recommends that the institutions, public and private, surrounding the decision process are themselves properly the objects of detailed study. In this regard, the task force suggests a need to study the feasibility of establishing a means which will facilitate effective communication between decision makers and the researchers, academic and otherwise, whose work offers the possibility of improving the decision process by making it responsive to changing human needs. It is possible that an intermediate institution (between decision makers and researchers) could function to bridge the communications gap.

3. The task force members are agreed that research efforts of the various social sciences directed toward development of techniques to monitor and measure individual and group preferences are of considerable importance. However, it is only as such measurements are expressed as objective indexes which are either commensurate with the typical elements of the resource-use decision (for example, measures, such as dollars, common to the market), or which allow relevant trade-offs among different elements to be formulated, that human needs and preferences can be systematically accounted for in the decision process. Thus, it is unfortunate that the measures developed by the various disciplines often are not directly useful to the decision-maker in the manner just described. That they can become so is beyond question. Therefore, the task force recommends that efforts to include preferences in the decision process through the use of objective indexes be strongly encouraged, but that the techniques be developed from the point of view of the requirements of the decision maker and not solely from the dictates of a particular discipline. What is called for, again, is a multidisciplinary approach, emphasizing common objectives, common methods, and a common terminology.



C. INSTITUTIONAL ARRANGEMENTS

**Task Force Leaders: Arnold W. Bolle and
Terry D. Edgmon**



**TASK FORCE
ON
INSTITUTIONAL ARRANGEMENTS**

**Final Report
June 24, 1974**

for

ROCKY MOUNTAIN ENVIRONMENTAL RESEARCH

Quest for a Future

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1: INTRODUCTION

The broad objectives set for this task force were to develop research priorities within the area of "institutional arrangements" in environmental affairs for the Rocky Mountain Region and to determine the present state-of-the-art in this area. We shall begin by discussing the definitions agreed on by the task force for the terms "institutional arrangements," "environmental affairs," and "state-of-the-art" as they delineate the scope of this report.

1.1: Institutional Arrangements

Institutional arrangements can be defined as "patterns of relationships among persons and groups which facilitate and influence public choice and decisions." Institutional arrangements also deal with property concepts that derive from the common law heritage of the English tradition and with the terms under which the resources are owned, leased, transferred, used, etc. An example is the deer herds of the oil shale area which are state property while the habitat is predominantly federally owned land.

In addition, institutional relationships among persons and groups often result in decisions being made among various courses of action permitted under law, primarily on the basis of values or ethical standards (public choice).

The central question for the task force in preparing this report has been:

What research will lead to the enhancement of public choice by providing a knowledge base for the decision maker and the public?

Such information may concern the state of the physical environment, provide understanding of social values held by the community, and enable both decision makers and the public to understand the environmental and socioeconomic consequences of various policy choices. Most of the other RMER-Quest task forces are engaged in recommending research priorities in factual and substantive areas. Therefore, recommendations of this task force are aimed at improving the process of decision making by suggesting research which will improve the knowledge base utilized by decision makers in government and by the public.

1.2: Environmental Affairs

The term environmental affairs may be defined as "any aspect of the relationships among man, his society and the environment." Environmental affairs are particularly salient to the populace of the Rocky Mountain Region, in that it contains many thousands of square miles of arid to semiarid natural environment, is relatively undeveloped industrially, has low population density, and a significantly large percentage of its land and mineral rights are federally owned.

The Region is natural resource intensive, and there are presently many proposals for utilizing these resources. There exists a need to balance national needs with regional values. State, Federal and local governments share responsibility for regulating natural resource development while maintaining environmental quality. Each government in turn fragments administrative authority among its agencies and departments which sometimes pursue conflicting goals or have overlapping authority. (In fact, it is noted that where authorities overlap the same geographic area or other area of concern, the facility to function is lost or weakened until the only course of action becomes no action.)

Just as authority and responsibility in environmental policy is fragmented in our governmental system, so too, our knowledge of the relationships of man and his society to the environment is fragmented. Even researchers in environment and the development of a natural resource policy tend to specialize within a single academic discipline.

1.3: State-of-the-Art

It should be noted that "state-of-the-art" surveys are used most frequently in the engineering and "hard" sciences where they are generally seen as the first step in the process of developing research plans and proposals. However, in the social, behavioral and management sciences, state-of-the-art surveys are used less frequently because these disciplines do not share a common theoretical base. Also, progressive linkages among the development of theory, methodology and empirical research do not exist. In general, the relationship of social science knowledge to the conduct of human affairs is problem oriented. The development of applied social science knowledge can be seen to cluster around significant socioeconomic problems. Theory development, on the other hand, tends to cluster around ideas deemed significant by the members of each social science discipline.

Because of this state of affairs, a state-of-the-art survey can possess a variety of meanings. Does it mean a survey of the state of theoretical knowledge in the social sciences? Does it refer to the body of empirical findings concerning the effects of institutional processes in the resolution or regulation of identified socio-economic problems? Or does it refer to the present state of our society's rules and arrangements concerning decisions?

As a further consideration, state-of-the-art surveys are useful if they serve to link theory development to empirical research and empirical research to applied problem solving. In social sciences, especially in terms of our theories of institutional arrangements, the linkage between knowledge and problem solving action is not self-evident or automatic. Creating and modifying institutions and the arrangements among them requires significant value choices to be made by society. Social scientists alone cannot affect changes in social or institutional relationships.

For purposes of this exercise, therefore, "state-of-the-art" shall be assumed to refer to the compilation of those empirical findings which address significant aspects of institutional arrangements related to the development of public policy in environmental affairs. Our research priority listing, however, will focus on problems of institutional arrangements which are significant in the development of public policy in environmental affairs in the Rocky Mountain West.

1.4: Research Assessment Strategy

Given the breadth of the concept of institutional arrangements, the scope and complexity of public and private relations within the Region, and the fragmented nature of our knowledge, the task force has bounded its investigation by adopting the following strategy:

1. Consideration of institutional arrangements in substantive policy areas, such as timber and range, water resources, second home and residential development, recreation, and energy resource development, will be left to the other task force groups. Rather than breaking down our report into a series of discussions on the institutional arrangements in each substantive policy area, this task force will take an overview of the environmental resource decision-making process. That is, we will concentrate on decision-making processes which cut across all substantive study areas, such as energy, water, timber and range resources, residential and second home development, and recreation. The focus is on regional policy decisions and the individuals and groups (public and private) which make or affect those decisions.
2. Given the above focus on decision processes, we shall divide our investigation of institutional arrangements into four levels of action. The levels are:
 - a) **Intergovernmental:** the relations of the various units of government of the Rocky Mountain West to each other, and to the Federal Government.
 - b) **Policy administration and state government:** the relations of administrators as organizers of policy decisions and the affairs of the states in the Rocky Mountain West,
 - c) **Managerial:** the relationship of land or resource managers to individuals, groups and organizations within the community, as this relationship affects environmental decision making.
 - d) **Forms of citizen and group participation:** the relations of organized and unorganized publics, including advisory groups, to all levels of government.

1.5: Research Assessment Priorities

Within the above framework, the task force addressed itself to the problem of identifying research which will lead to the provision of incentives and the generation of

information related to the development of environment-related public policies that will reflect the social and environmental values held by the population of the Rocky Mountain States at a time when many are looking to this Region for the production of resources deemed vital to the welfare of the Nation. As the task force examined possible research topics in light of this, a number of priorities for research assessment emerged:

Priority 1. The first concern of the task force relates to the importance of information concerning the status of the physical environment and knowledge of changes in that status as a result of human enterprise. The task force agrees that, at present, most information resources are held by groups and organizations who stand to gain economically from certain decisions made by public agencies. In many cases, however, government agencies have developed a dependency relationship with these groups and organizations and rely upon them for information which serves as the basis for policy decisions. Often, therefore, the decisions of these agencies may reflect the interests of these groups and organizations, rather than the wide interests of the public at large. State regulatory agencies provide good examples of this phenomena. Therefore, the task force recommends that the highest priority be given to research which considers alternative methods by which information may be made available on a systematic basis to public decision makers, groups and the public who will be affected by public policy decisions of governmental agencies.

Priority 2. The second major concern of the task force focuses upon the relation of the resource or land manager to the public and his capabilities to plan adequately for the public's diverse interests with respect to resource allocation decisions. Of particular concern is the development of new tools for environmental management, adequate forecasting methodologies and planning procedures which will allow for the widest range of public participation in advance of irrevocable decisions. Therefore, the second highest priority will be given to research which leads to the development of land and resource management planning and decision procedures which adequately provide for and include information derived from groups and organizations who have an interest in the decisions made for them by public land and resource managers.

Priority 3. The third major concern of the task force focuses upon the implications of the emergence of groups and organizations which represent new environmental concerns and are re-examining the current thrust of public policy in environmental affairs. Various "communities" of interests in environmental affairs cut across governmental boundaries and agency jurisdictions. Current political-geographical boundaries reflect the values and concerns of an earlier age. While these boundaries have tended to remain static, interest and value configurations have changed over time. Since it is these broad configurations of interests in our society which provide the motive force for institutional change, the task force recommends that the

third highest priority be assigned to research which will identify changes in the various "communities" of interests which cut across governmental boundaries.

Priority 4. Finally, the task force realizes that, as social values and economic requirements change, so too must our institutions. In addition, our public institutions must somehow develop the capability of determining the social and environmental costs of future development and strike an acceptable balance between the maintenance of a quality environment and natural resource development. Also, they must formulate, enact and administer appropriate guidance systems for the regulation and control of development which will assure the protection of the environment. Therefore, the fourth level of priority will be assigned to research aimed at the modification of existing institutional arrangements and the creation of new ones; and which will lead to the development of public policies that take into account the environmental and social costs and benefits of natural resource development within the context of maintaining an acceptable level of environmental quality.

1.6: Summary

This task force has taken its responsibility to be the attempt to identify research areas which, if pursued, may lead to the enhancement of public choice by providing a knowledge base for decision makers and the public. Moreover, the group has chosen to focus on institutional elements related to the general process of decision making in environmental affairs, rather than listing problems in

substantive policy areas. In examining the decision process, the task force has divided its investigation according to four levels of action: intergovernmental; administrative, state legislative and governmental; managerial; and citizen participation. Table 1 illustrates the major research topics subsumed under each of these divisions. Under each topic, a number of researchable issues have been articulated.

Among these divisions, priority ranking has been developed. Research receiving our **highest** priority are those topics and issues which, if pursued, would lead to the generation of pertinent information to be used by agencies, groups, organizations, and the public for policy decision making. The second priority research topic includes those research topics leading to the development of land and resource management planning and decision procedures which adequately provide for information derived from groups and organizations who have an interest in the decisions made for them by public land and resource managers. The **third** priority level for research deals with the identification of changes in the configuration of interests and values within the Region. And finally, the **fourth** priority rank deals with research topics which address the problems of developing institutions which have the capability to take into account the environmental and social costs and benefits of natural resource development within the context of maintaining an acceptable level of environmental quality.

Following will be a problem assessment for each of the four levels of action in the environmental policy decision process and a listing of areas of needed research.

Table 1
Summary of Institutional Problem Areas and Research Areas

Research Areas	Problem Areas			
	Policy Administration and State Government			
	Intergovernmental	Management	Citizen Participation	
Interstate organization	Modification of environmental administrative systems	Management models and planning procedures	Public information systems	
Impact of federal resource development policies	Comprehensive land use planning	Natural resource management technology transfer	Participation procedures	
	Science advocacy			
	Population migration			

2: PROBLEM ASSESSMENT

Problems of institutional arrangements in the Rocky Mountain West can be seen to exist on four levels of action. These levels correspond to four levels of decision making within public organizations and institutions: 1) the intergovernmental level, or relations among the States and between the States and the Federal Government in our federal system; 2) state governments policy administration, or the relations of States to other institutions, and the relations among operating agencies of the State, Federal and local governments; 3) the managerial level, or relations among managers, the environment, and elements within the community; and 4) public participation, or the linkages of various publics to the decision process. We shall now discuss what we consider to be major problems on these levels.

2.1: Intergovernmental Problem Areas

A rational environmental policy (that which balances development with environmental quality) demands a comprehensive and integrated approach to the many interrelated aspects of the physical environment: air, water and land. Viable solutions to environmental problems also demand foresight. The secondary effects of proposed and current actions -- strip mining, second home development and ground water mining -- must be projected into the future. Existing institutional arrangements allow neither integrative decision making nor planning.

Of major concern to the task force is the emerging relationship of the Rocky Mountain States to the rest of the Nation with respect to the mounting demand for large-scale energy resource development. Planned solutions to the Nation's energy short-fall include exploitation of the abundant supplies of energy resources within our Region. A large percentage of the land within this Region is federally owned and managed. The recent leasing of federal land in Colorado for prototype oil shale development, for example, at an excess of \$40,000 per acre, is an indicator of the magnitude of financial investment, the scale of eventual development, and the economic value and importance of these lands. As the intensity of this development increases, in an effort to keep pace with the rising demand for domestic energy resources, so will regional interest groups intensify their activity to protect and preserve traditional values of the Region and its physical environment.

The problem soon to face state and federal policy makers contains the following elements: 1) the study region is rich in natural resources, yet this treasure is embedded in fragile ecological systems; 2) national pressures are mounting for the expansion of development of these resources, development at the least economic and social cost to the Nation as a whole; 3) development at the least national (or corporate) cost may impose high social and environmental costs upon the public of the study region. Therefore, the public and

their policy makers must develop an awareness of the regional social and environmental costs of large-scale natural resource development ventures and begin to prepare for the sound and orderly development of the Rocky Mountain Region. The basic problem facing our public institutions, then, is how to develop the capability to determine the social and environmental costs of future development, strike an acceptable balance between the maintenance of environmental quality and natural resource development, and enforce laws which preserve and protect unique ecological systems while allowing for balanced natural resource development which serves the Nation and increases the welfare of the public.

At the present time there are few regional interstate institutional arrangements which provide for mechanisms which balance national needs with regional values and interests. Some have suggested that the lack of interstate resource policy reflects a lack of a commonality of interests among the States. However, in recent years we have seen the growth of organizations and activities which are working toward the goal of developing a consensus within the Rocky Mountain States with respect to a regional environmental policy. The Federation of Rocky Mountain States, Rocky Mountain Center on the Environment and RMER-Quest, among others, are initial attempts to develop an interstate awareness of common interests and a capability to arrive at mutually satisfactory solutions to problems faced by States within the Region.

The major needs related to the problem of interstate institutional arrangements are as follows:

1. The need for interstate regional organization or organizations able to strike a balance between national needs and regional values with respect to large-scale natural resource development within the Region.
2. The need to determine the costs and benefits of interstate natural resource development and the impact of federal resource development policies, including their social, economic and environmental costs to the Region.
3. The need to develop an interstate information system or network and data base so that policy makers on this level will be able to make informed decisions.
4. The need for mechanisms to aggregate social preferences and values within the Region.

2.2: State Government and Policy Administration in Environmental Affairs

Ours is a fragmented political system: environmental decisions are parceled out to hundreds of boards, commissions, agencies, and departments. This division of labor usually follows functional lines. Therefore, environmental policy for the Rocky Mountain States is the sum of incremental decisions made by organizations who usually have authority over only one small aspect of the

environment in one small jurisdiction. This piecemeal approach, while allowing multiple access points for private interests, inhibits the development of public awareness of the implications of decisions made in one jurisdiction for another. As ecosystems reach their carrying capacities, the inefficiency of this decision mode may be reflected in irreparable damage to the Region's environment and a decline in the quality of life.

At the same time, however, there are several trends causing institutions to develop arrangements which will coordinate decisions and anticipate the impact of public and private decisions on the environment. Foremost among these are court enforcement of the National Environmental Policy Act, the growing relevance to the States of the environmental impact statement (EIS), emerging state land use policy through the passage of land use legislation, and recent attempts to develop technology assessment methodologies which account for social and environmental effects of the use of new technology.

Needs related to the problem of the organization of environmental policy systems are:

1. The need to modify environmental management systems to integrate environmental impact statements with plans and implementation procedures on all governmental levels.
2. The need for comprehensive planning organizations with authority to implement plans on the state and substate level.
3. The need to develop evaluation procedures, standards and criteria to assess the performance of institutions and the impact of new technology on society and the environment.
4. The need to integrate knowledge concerning our environment with the capability for legislative action on the state level through science advocacy.
5. The need to assess the impact of migration upon the demand for public services within the States of the study region.

2.3: Environmental Management

The third level of public decision making involves the interaction of managers with a series of technical problems and an attentive public. In this regard, the task force has recognized that problems exist with the analytical tools employed by the manager to ascertain alternative resource allocation options; the transfer of knowledge from the researcher to management use; and the transfer of social objectives to the manager from elements within the community. Since these processes occur within sets of institutional arrangements, the task force has identified the following problems.

Resource management requires a fairly high degree of technical skill, a reliance upon empirical data, and the employment of sophisticated resource allocation models.

However, these analytical tools currently rely heavily upon economic variables. Managers have difficulty accounting for non-economic variables and for values held by individuals and groups who do not stand to benefit directly from a management decision on resource allocation. This problem is a technical manifestation of the wider conflict between resource developers and concerned environmentalists. To the extent that the latter group is concerned with secondary and higher order consequences of resource development of ecological and social systems, and that these costs are not considered in the initial decision processes of land managers, this problem cannot be resolved through an analytical procedure by management. Rather, resource allocation decisions will be determined through a conflict resolution process. A major need, therefore, is to develop analytical procedures whereby secondary and higher order consequences of resource allocation decisions can be accounted for in initial managerial analysis and decisions.

Another major problem faced by managers is the slow transfer of management technology from the shelf to operational usage. This becomes a critical factor when the decision circumstances of the manager undergo a rapid change. To a large extent, the problems land managers face today are not the same ones encountered five to ten years ago. Yet the problems they face may be similar to those experienced by managers in other areas of society. Therefore, the task force recognizes a need to develop or modify existing institutional arrangements so that natural resource managers may benefit from relevant knowledge and experience existing in other parts of the social system.

Thus, the task force recognizes the need for:

1. The development of analytical tools for management which account for secondary and higher order consequences of land use and resource allocation decisions.
2. The development of arrangements to facilitate the transfer of appropriate existing knowledge to resource managers.

2.4: Public Participation and Public Information

In communities where a conflict over social goals and objectives exists, land managers have difficulty determining a socially desirable pattern of resource allocation. Citizen participation in resource decisions has traditionally been limited to user or clientele groups such as land developers, cattle grazers, loggers, miners, etc. The traditional mechanism has been the advisory board which is usually composed of representatives of these users. Recently, however, both citizens and agency personnel have articulated a growing dissatisfaction and frustration with such arrangements. New groups representing a shift of values in communities and in society at large find such arrangements exclude them from decisions considered salient to their interests. Persons in these groups generally pay, through taxes, the same as users do for the

management of semi-primitive areas. Yet, in many cases their values are either not perceived by the manager or not taken into account in the decision process. Also, because many environmental management decisions are based upon the analysis of data, community groups oftentimes find that managers possess a monopoly of the information needed to determine where a group's interests lie among a range of decision alternatives.

Consequently, the task force recognizes the need for research in innovative techniques in citizen participation to "open up" the decision process of land managers, and in arrangements to make scientific and technical information and interpretation available and understandable to citizen groups. Therefore, the major identified needs in this area are:

1. The need to develop techniques of citizen participation that allow for the incorporation of a wider spectrum of community interests in resource allocation decision processes.
2. The need to develop information systems and an analytical capability which facilitates informed citizen participation in management decisions.

3: AREAS OF NEEDED RESEARCH

3.1: State-of-the-Art

While students of institutional arrangements are cognizant of each of these above problems, little basic research has been applied to their causes and solutions. The existing literature can be characterized as follows.*

1. Few scholars have broad and continuing interests in the field. For example, solutions to our energy and environmental problems will require an interdisciplinary approach. Economists, political scientists, physical scientists, planners, landscape architects, ecologists, and engineers will need to communicate and to integrate their various skills and perspectives. Presently, however, energy and the environment are treated in narrow disciplinary terms, and there is a tendency to disregard political and institutional restraints when technical solutions are proposed. Interdisciplinary teams are just learning to communicate and develop conceptual tools for environmental analysis. The Grasslands Regional Systems Program, Lake Powell Research Project, and the Lake Tahoe Research Project (NSF-RANN) are examples of recent, interdisciplinary efforts. New institutional arrangements within our academic communities are needed to develop incentives for cross-disciplinary research and development if a coherent body of knowledge is to emerge.

*The following categories are derived from David F. Paulsen, *Natural Resources in the Governmental Process*, Tucson, University of Arizona Press, 1970.

2. Most of the literature which exists is narrow in focus. Some relates to particular resources or agencies. There have been few attempts to integrate these specific studies.

3. The field lacks bibliographic and reference material. Bibliographic material which exists relates to resources rather than the environment. There are few listings of environmental and civic groups. While many efforts are beginning in various States in the Region, this information is not available on a uniform basis.

4. Many important areas of study are neglected. Little is written or known about counties, state legislatures, interest groups, courts, Indian councils, and administrative agencies in the States within the study region. Most of the studies which do exist are case studies and do not examine general decision processes attributable to specific institutional arrangements, nor do they compare outcomes of decisions from a number of different institutional arrangements. The dearth of comparative studies makes systematic evaluation and research on institutional arrangements difficult, if not impossible, at this time.

As the above sketch of the state-of-the-art makes clear, we need more descriptive baseline data on existing institutional arrangements and their impacts upon policy development and action. A selective bibliography of representative works related to the problems addressed throughout concludes this report. Without an understanding of the current institutional patterns, it is difficult to forecast what impact any proposed modifications might have on decision making. Both time and resources for the needed inventory of existing institutional arrangements are lacking. Short of the comprehensive investigation of environmental decision processes (which should be of the highest priority), the following are suggested as areas of research where information would be immediately useful.

3.2: Intergovernmental Considerations

In this section the task force considers problems of institutional arrangements related to the function of our federal system. First, the problem of striking a regional-federal balance in terms of social costs and benefits of large-scale energy resource development will be considered. And secondly, the problem of federal policy impacts within the Region will be discussed.

3.2.1: Interstate Regional Organizations

Natural resource development on a multi-state scale is fast becoming a reality. Great social and environmental costs to the Region will allegedly occur if this development is left to the Federal Government and private enterprise. There is a need to conduct research to determine, as precisely as possible, the social and environmental costs of such development to the Rocky Mountain Region. Also, institutional mechanisms will have to be developed to

manage conflicts of interests and values on the interstate level, and to plan for the balanced and orderly development of natural resources in multi-state regions. The task force therefore recommends:

1. Studies which look at possible socioeconomic trade-offs among multiple resource uses between the States and regions within the States affected by large-scale natural resource development. For example, what will be the impact of oil shale development upon the availability of water supplies for agriculture and other uses? What will be the costs to rural counties to provide urban services to an expanding population? What fiscal arrangements need to be considered to provide the States and counties with the capital necessary to support coal development? What planning arrangements need to be made for mineral resource fields which span more than one State?

2. Studies which determine the socioeconomic limitations of resource development areas with respect to energy resource extraction, water use, recreation, and rapid urbanization. How can the costs of "boom and bust" development be redistributed to those who will benefit directly from rapid industrial development of rural areas?

3. Policy analyses which determine patterns of values and groups or organizations which may serve as the basis of support for interstate planning institutions. Is there a community of interests within the Rocky Mountain Region? If so, where; to what extent? Are there common interests which coincide with identified environmental problemsheds areas that cut across governmental boundaries? Will support for interstate cooperation emerge from state executive offices? What role will state legislators play?

Studies which will ascertain the potential constituencies for development of coalitions of interests to support interstate organization. Who will be the representatives for an interstate interest?

5. Feasibility studies of appropriate institutional arrangements (including coalitions) which will have the potential for balancing regional values with national needs. What kinds of regional institutions might be established with the necessary comprehensive jurisdiction over river basins, airsheds and geographical entities? Are there regional mechanisms existing elsewhere which could serve as a basis for institutional innovation within this Region? What are the incentives and disincentives of present decision makers, i.e., state and federal agencies, to relinquish authority to regional bodies and to cooperate with such extra-state entities? What forms of state and federal legislation are needed to transfer authority from the States and the Federal Government to a regional institution? What appropriate arrangements can provide for the development of an interstate information system, and environmental monitoring capability, forums for debate, dissemination of information, and interstate policy formation?

3.2.2: The Impact of Federal Programs on the Rocky Mountain West

A fundamental problem with a federal system of government is the impact of one level of government's programmatic goals on another. In respect to federal resource development goals and programs, the environmental, social and economic impacts and implications are not known, but anticipated. It is reasonable to assume that federal resource development programs in the study region are already beginning to substantially affect the demand and supply of state, county and municipal public services. For example, federal leasing of public lands for mineral extraction has already shifted the public expenditure patterns of States, counties and municipalities already affected.

Conversely, the Federal Government has employed a variety of tools to implement federal policies. Investment and subsidies have been designed to encourage specific types of economic enterprises; for example, the 160-acre limit placed on reclamation benefits. More recently, the Federal Environmental Protection Agency has allocated grants and formulated regulations to promote quality environment. What has been the actual impact of these policies? Which federal programs work at cross-purposes, i.e., promoting growth and development without due regard to environmental quality? To what extent have the States, often given the task of implementation, substituted their own goals and objectives? What unanticipated consequences have emerged which distort the impact of federal policies? Noting the lack of documentation on the impact of federal natural resource policies upon the Rocky Mountain States, the task force recommends:

1. The investigation of the impact of federal resource development policies upon the environment of the Rocky Mountain States.

2. Analysis of intergovernmental cooperation and coordination of programs and projects serving national goals.

3. Investigation of the possible role of the Federal Regional Council to act as coordinator of regional federal agency resource development policy and projects within the Region.

3.3: State Legislative and Governmental Administrative Considerations

In this section the task force considers research needs based upon identified problems in environmental policy systems. These include problems arising from the utilization of the environmental impact statement (EIS), trends in state land-use legislation, technology assessment, science advocacy, and studies which would ascertain the impact of migration upon the Rocky Mountain States.

3.3.1: NEPA and Environmental Accountability

The passage of the National Environmental Policy Act has made many federal agencies accountable for planning their resource administrative programs with an awareness of the relationship of their programs to the environment. The act specifies not only an assessment of environmental impacts, but also a conscious recognition of their decision processes in selecting alternative courses of action. At this time, however, it is not clear what the emerging relationship is between the environmental impact statement (EIS) and agency planning and implementation. Does the EIS significantly influence the planning process? Do agencies possess sufficient expertise and information to make EIS relevant? What will be the next stage in the development of environmental impact consideration? How can the EIS be made a viable planning tool? Our lack of knowledge concerning the relevance of EIS compels the task force to list the following research priorities:

1. Comparative studies of the impact of EIS on planning decisions.
2. Assessments of administrative problems created by NEPA. What modifications in law would be needed to insure the evaluation of environmental and social values with economic ones?
3. Research on alternative administrative systems, which would give agencies the capability to make significant choices from a range of viable options.
4. The development of environmental standards and criteria, so that alternative courses of action can be systematically evaluated from outside the affected agency.
5. The development of analytical capabilities of States and counties to evaluate the results of EIS from federal and private organizations.

3.3.2: Land Use Planning and Implementation

Because the Federal Government manages an extremely large portion of the Region's land area and the increasing pressure on the States to develop land use policies, the States are now beginning to consider and pass land use legislation. Heretofore, they have generally taken a *laissez faire* approach. Adverse effects of land development have been recognized after the fact, rather than anticipated through research and directed through planning. Land use policy planning, as it is developing in many states, requires the coordination of agencies on all levels of governments: federal, state and local. Before ecosystems reach their limits of use by humans, foresight and intergovernmental coordination may prevent ecological disasters and maintain environmental quality with resource and urban development. Therefore, the task force recommends the following research areas pertaining to land use policy development:

1. To what extent are the States presently capable of land use planning and environmental assessment? What land use regulatory agencies presently exist? What are their legal mandates, levels of funding, and numbers and interdisciplinary skills of their personnel? How do various functional planning agencies (i.e., land, water, air) relate to one another in planning? To what extent are inter-agency committees and procedures for clearance and approval of plans effective? How do integrated environmental and land use planning agencies work in the Rocky Mountain States where they have been established?

2. To what extent do state legislatures represent the various interests concerned with land use? What has been the effect of reapportionment upon representation? How does the state legislator conceive of his role? Where do state legislators get information for environmental decision making? What kinds of incentives exist for state legislators to support regional institutions which threaten state autonomy?

3. Many of the same questions which need to be investigated in respect to the state legislatures are applicable to the counties. Additionally, the role of county planning and zoning authority needs study.

4. What are the emerging roles and responsibilities of cities, counties, special districts, and regions in respect to land use?

5. What are the various roles of federal agencies (e.g., SCS, BLM, USGS, AEC, Forest Service, Corps of Engineers) in land use planning?

6. What are the emerging roles and responsibilities of regional councils of governments (COGs) now that USDA and the Department of the Interior agencies are included in the A-95 review process? What are the incentives and disincentives of local governments, federal and state agencies to cooperate on the substate planning level in respect to semiprimitive lands?

3.3.3: Technology Assessment

At base, concern for environmental quality is an expression of the belief that values other than narrow economic maximization should guide society and development in our society. In the American tradition of resource development, focus has been on the assessment of technological and economic costs and benefits. Other types of costs, either to society or to the environment, were considered only after development. Thus, we were often locked into developments and, as an afterthought, often utilized technology to reduce the secondary costs created by the original technology. Unfortunately, secondary costs and adverse consequences of technological fixes are usually

discovered fairly late in the game. A major national shortcoming is the failure to design institutions which encourage the determination of social and environmental effects of anticipated technologies.

This problem is of particular concern to the people of the Rocky Mountain Region as new resource extraction and refining technologies are applied. How will these technologies be evaluated, and how will the public gain access to the evaluations and the data bases from which they were derived?

The task force recommends that a major research and development goal be the design of institutional arrangements capable of: a) evaluating social and environmental consequences of alternative technological development policies and, on the basis of these evaluations, b) making decisions aimed at reducing social costs. Before evaluative institutional arrangements can be considered, however, research must be directed toward the development of standards for balancing social costs and benefits.

Improved methods for evaluating institutions and policies are closely related to the problem of developing adequate social and environmental indicators. The evaluation of technological development in respect to these indicators, organized around discrete regional resources, should provide an improved understanding of the overall impacts of future development in the Rocky Mountain Region. For example, coal technology assessment should provide a description and evaluation of the half-dozen technological options which are used or potentially available and a comprehensive overview of the social consequences of coal development. Such an assessment necessarily includes identifying and evaluating institutional arrangements. In evaluating the capability of existing institutional arrangements to manage future regional development, it is essential that the evaluation be related to both development activities associated with specific technological options and to the capability of existing institutions to manage and control development for the highest possible social benefit.

3.3.4: Science Advocacy

Decision makers in the Rocky Mountain Region will be deciding important questions of resource allocation and development with or without adequate information on environmental impact. Much necessary information is not generated under current institutional arrangements. Also, decision makers and their constituencies do not have the resources to evaluate and assimilate the information they do receive. In short, our institutional structures and processes are not organized to mobilize fully the problem-solving capacity in our society. It is clear that public policy formation and decision-making processes can be strengthened by more closely linking them to the knowledge resources, research capability and public educational processes located within the Rocky Mountain States.

One particularly vital link, which appears in several other places in this report, is the great disparity between the informational resources available to those who stand to profit from resource use decisions and to those members of the general public who wish to understand the issues and perhaps to contest the developmental proposals that result. Often government stands, with industry, on the side of the "information rich," further limiting society's capability to mobilize its full resources to solve problems.

The task force therefore recognizes that efforts should be made to integrate knowledge resources with decision-making processes. This may take on many forms, as suggested below:

1. A science advisory and public policy council, with representatives from the scientific community and the makers of public policy of the Region, to articulate problem-oriented research goals and work with interstate planning organizations.
2. State planning conferences on natural resource policies, where state-of-the-art information may be readily transferred to state executives and legislators, and where contending sides of a policy issue may receive the benefit of existing knowledge and information.
3. Information systems and data bases on the state level so decision makers may better understand the implications of various policy choices on the environment.

3.3.5: The Impact of Population Migration on Existing Institutions and Policies

The Rocky Mountain Region is experiencing rapid rates of growth. This rapid growth will accelerate if the oil shale and coal industry develop fully, followed by increased demands for public services. There is reason to believe that immigration to the Region will be on a selective basis. These new individuals may possess different preferences for government services than the "natives." Such differences in preferences will tend to produce intergroup conflict. When attempting to design or modify institutions to deal with problems of increasing population growth, decision makers will find it difficult to avoid issues related to modifications in the pattern of existing governmental services. We need to know the implications of such rapid growth rates upon decision making, i.e., voting patterns and the orientation of state legislators and executives. The task force therefore recognizes the following research needs:

1. What will be the effect of population growth and change on political institutions on the state and local levels?
2. What will be the impact of differing rates of population growth on political and social institutions, on political demands, and on the allocation of governmental services?

3. What will be the impact of varying racial, religious or ethnic composition of immigrating populations on existing patterns of political participation, interest aggregation, demand for government services, political decisions, and budgetary priorities?

4. What will be the voting behavior and interest group formation of migrants to the Region?

3.4: Environmental Management

The management of ecological systems requires two basic elements: ecological information and knowledge of social preferences. Trends are toward modeling and use of feedback loops. The function of environmental management systems, then is to satisfy social wants without degrading the physical and biological environment to the point where present or future social preferences cannot be met.

In recent years we have witnessed a shift in expressed social preferences concerning the management objectives of semi-primitive areas in the public domain. Traditional land management practices are oriented towards resource development. Management problems were formulated in terms of optimizing resource outputs at minimum development costs. If public participation was allowed at all, it was limited to resource users: loggers, miners and cattlemen. Recently, however, public land managers have been confronted by groups and organizations which articulate different social preferences than user groups, and herein lies the problem for land managers.

For example, compare federal regional office management (i.e., Forest Service) with federal/state office management (i.e., BLM and SCS) as to effectiveness in coping with special interests versus public interest pressures in resource management decisions. Summarizing from our problem statement in Section 2, the emergence of groups seeking alternative use of public lands has created the following problems.

3.4.1: Management Models

Most management analytical tools employed by land managers today are oriented to the "optimization" of resource outputs. These include cost-benefit analyses, linear, and goal programming routines. In more advanced decision models, such as ecological simulations, environmental factors are weighed against economic criteria. However, these tools generally do not allow the manager to balance non-economic values (or values held by individuals and groups who do not stand to benefit directly or lose financially from a resource management resource allocation decision) against economic ones.

To the extent that a manager's analytical tools do not (or cannot) account for significant non-economic values, then

the manager cannot, in an analytical fashion, reconcile them with economic values. The reconciliation of these conflicting values will therefore occur within court proceedings or the political process. An additional problem arises: to what extent are federal policies modified at the managerial level, and in response to what forces?

Therefore, the task force recognizes the need for research in resource allocation decision methodologies which may lead to the development of techniques which may account for a wider range of social preferences.

3.4.2: Transfer of Natural Resource Management Technology

The research need mentioned above cites the need for research and development of management analytical techniques which will incorporate a wider spectrum of social preferences than the existing technology allows. The second need therefore concerns itself with the research related to aiding the transfer of these new techniques from the university or research institute to the field. Given the rapid shifts in social preferences and increased demands for resources, traditional modes of technology transfer, through professional associations, academic and career training, generational change, and "refresher" courses, may not meet the demand. Also, as the decision making circumstances change, existing knowledge in other fields once perceived as irrelevant may become pertinent to resource management's needs.

The task force, therefore, recommends research on institutional arrangements which will increase the rate of technology transfer from the academic or research setting to the field, and the rate of management problem recognition from the field to the universities and research centers. How well do "extension" services work? What retraining programs should be offered to land managers who must manage social conflicts between environmentalists and traditional resource users in semi-primitive areas? What disciplines possess knowledge which is relevant to the current problems facing land managers?

3.5: Public Participation

If a consensus can be said to exist among members of the task force and the personnel interviewed in public agencies by members of the task force, it is on the question of citizen participation. There has been almost universal mention of the needs for a greater understanding of how public participation can be made more effective. Agencies, public groups and others are struggling with this problem. Constructive public participation is not yet a fact, except in a few isolated cases. Agencies want to institutionalize the process. They think in terms of handbooks rather than social processes. They fear loss of agency prerogatives. Private groups feel frustrated. Their only opportunities and

experience have been largely in adversary relationship on the one hand or as co-opted groups on the other. Research into experience in other areas (in cases of success in resource management with trials based on well-known principles in new organizations or arrangements) is badly needed throughout the bureaucracy. The groups with stakes, even vicarious, in environmental decisions need to be identified. To whom do they communicate? What are their patterns of interaction with governmental agencies, with industry? What are the institutional mechanisms which can effectively increase citizen involvement? What is the role of the public hearing? What is the effect of the environmental impact statement process upon channels of communication and modes of participation?

One example of members of the public frequently not included in lists of people who are interested in environmental issues is American Indians who control a significant land area in the Region.

3.5.1: Public Information

One of the major impediments to effective public participation is the general inability of the public to acquire access to the environmental information they need to determine where their interests lie in the management of ecological systems. Comprehensive data bases and expertise are resources possessed by public agencies and economic interests. To the degree that some groups express values not deemed relevant or not preferred by public agencies, they are generally denied access to critical information.

The task force therefore recommends that research on alternative institutional arrangements be conducted towards the end of developing information systems and analytical capabilities which would be available to the public at large, so that groups could evaluate management options in terms of their effects upon the groups self interests.

Specifically, research strategies and funding are needed to create and support science advocacy/information organizations. Ways must be developed to place the information from these organizations at the disposal of members of the public who do not have a parity with industry and government in justifying or opposing development decisions. The issue here is availability of information in an advocacy (political) situation. An example of an organization which has had immense impact in the field of preserving natural areas by providing professional expertise to public groups is the Nature Conservancy. In the field of science information there is the Scientists' Institute for Public Information and its regional groups; in the field of science advocacy in the courts, the Environmental Defense Fund; regionally, in land use planning, Rocky Mountain Center on the Environment and COFE.

4: SUMMARY AND CONCLUSIONS

In a research assessment task, all recommended research topics appear to be equally relevant or the group discovers a major difficulty in developing criteria by which such topics can be ranked according to priority. In the area of institutional arrangements, this problem is no easier. Out of the seemingly infinite researchable areas within our broad domain, however, we have chosen to focus on those research areas which, if developed, would lead to the integration of knowledge with social values, in such a way that public choices on environmental issues would be both better informed and pertinent to articulated social wants and needs.

The four broad areas which should receive support, in order of priority, are: 1) research on citizen participation and public information; 2) research which will lead to the development of land and resource management planning procedures; 3) research leading to the identification of changes in the configuration of social values and interests related to the development of environmental policy making; and 4) research which may lead to the modification of existing institutional arrangements and the creation of new ones, which take into account the environmental and social costs and benefits of natural resource development within the context of maintaining an acceptable and desirable level of environmental quality.

Research on the problems of citizen participation in environmental and resource development decision making is considered to be of the **highest** priority because of the noted widespread dissatisfaction with current arrangements held by citizens and public officials alike. This almost universal demand for new arrangements and procedures prompts us to place the research topics pertaining to this area at the head of the list.

Research on problems of environmental and natural resource management and planning is our **second** priority area because of its close relationship with the basic problem of developing institutional arrangements for environmental management which reflect the preferences of those who are the most affected by these decisions. Also, land managers, highly skilled in the more technical aspects of their professions, now need to consider the adaptation and acquisition of skills which will allow them to consider more fully the human and social side of their enterprise. Thus, the second priority research area deals with those research topics which would lead to improvement in communication and decision making found in the relation between the resource or land manager and the public, and his capabilities adequately to plan for and consider the diverse interests of the public in respect to the process of managing resource allocations.

The third most important problem area highlights research topics which deal with the analysis of significant value changes in constituencies, groups and the public which affect environmental and resource decision making. Since the values held by various publics provide the impetus for institutional change, research in this area would lead to significant insights into the possibilities of institutional design which would meet changing demands and needs of the public.

Finally, the fourth highest priority research deals with the problem of changing or modifying institutions themselves. The task force feels that our public institutions must somehow develop the capacity to determine the social and environmental costs of future development and the capability to strike an acceptable balance between the

maintenance of a quality environment and natural resource development. To this end they must serve, by developing, enacting and administering laws and guidelines, as guidance systems for the regulation and control of development which will assure the protection of the environment.

In conclusion, the task force realizes that this report could cover only a small portion of the research needs in the area of institutional arrangements. The concept of institutional arrangements spans many disciplines and professions, and has only recently begun to receive the attention it has deserved. The task force hopes, therefore, that this effort will lead to the broadening and intensification of discussion and research in this vital aspect of research and action in environmental affairs.

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D. MINERAL AND ENERGY RESOURCES

Task Force Leader: H. William Welch

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RECOMMENDATIONS FOR RESEARCH RELATING TO ENVIRONMENTAL IMPACT OF MINING AND ASSOCIATED PROCESSING
OPERATIONS IN THE ROCKY MOUNTAIN AND ASSOCIATED HIGH PLAINS REGION

FINAL REPORT

TASK FORCE ON MINERAL AND ENERGY RESOURCES
ROCKY MOUNTAIN ENVIRONMENTAL RESEARCH PROJECT

Submitted by H. William Welch, Task Force Leader
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*"When we mean to build,
We first survey the plot, then draw the model;
And when we see the figure of the house,
Then must we rate the cost of the erection;
Which if we find outweighs ability,
What do we then but draw anew the model
In fewer offices, or at last desist
To build at all? Much more, in this great work,
Which is almost to pluck a kingdom down
And set another up, should we survey
The plot of situation and the model,
Consent upon a sure foundation,
Question surveyors, know our own estate,
How able such a work to undergo,*

*To weigh against his opposite; or else
We fortify in paper and in figures,
Using the names of men instead of men:
Like one that draws the model of a house
Beyond his power to build it; who, half through,
Gives o'er and leaves his part-created cost
A naked subject to the weeping clouds
And waste for churlish winter's tyranny."*

William Shakespeare

-Second Part of King Henry IV, Act I, Sc. III

PREFACE

The quotation by Shakespeare states concisely the major thrust of this report. The region of the Rocky Mountains and associated High Plains is on the threshold of a development which if allowed to proceed without "drawing a model" and "rating the cost" could have disastrous results.

This development is a greatly increased rate of exploitation of mineral resources of the Region. Those related to energy, particularly coal and oil shale, are in the public eye. To completely "survey the plot," however, the collective impact of these with fertilizer minerals phosphate, potash and ammonia (produced using hydrogen from natural gas or coal), structural metals such as copper, and many other miscellaneous minerals (totaling approximately 90) must be assessed--with environmental and social as well as economic relationships in mind.

This report attempts to set the stage by stating the urgency of the situation, defining the scope of the problem, and calling attention to the proliferation of on-going but uncoordinated activities which address the problem.

This is followed by identification of several categories of research needs within which 50 areas of research, classified by subject matter, are identified. Tables 1 and 5 summarize the mineral situation and research needs.

Subdivisions within each of the 50 areas are spelled out, where appropriate, to emphasize need for *specific* effort. Discussion accompanying the identified needs emphasizes the use-oriented approach which prevails throughout the report. Emphasis is placed on the need for comprehensive interactive system approaches.

The problem of priority assignment is discussed as introduction to a priority ranking which resulted from task force deliberations.

Research strategies are discussed which emphasize the need for a *campaign*, integrated approach to the issues as opposed to the piecemeal, fragmented approach. This is followed by recommendations of a non-research nature which in some cases suggest action rather than research, and in all cases relate to the conduct of research without necessarily relating to the specific subject matter of the research.

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1. Physiography of Region	II-D-10
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1. THE PROBLEM

1.1 Urgency of the Situation

The region of concern considered in this report includes Idaho, Montana, Wyoming, Colorado, Utah, Nevada, Arizona, New Mexico, and West Texas. Occasional statistics leave out West Texas and/or include one or more of the Dakotas, California, and Alaska. This region is involved in a situation of unique circumstances and urgency relative to mineral and energy resources. The amenities and scenic vistas of the Region have long attracted residents, industrial and commercial organizations, and tourists. The abundant mineral resources were the initial stimulus for the development of the Region and for bringing the railroad to the Region which without navigable rivers, needed the railroad for sustained growth. Other forms of transportation and communication have displaced the railroad and made possible forms of industrial development and employment which take advantage of the amenities to attract people. These developments have de-emphasized the importance of mining activities in recent years.

The sudden awareness of a well-known and little understood phenomenon which we variously refer to as the energy crisis, crunch, or dilemma has brought attention to the fact that the region contains over half of the potential coal, a third of the oil and natural gas (if Alaska is included), almost 100 percent of the uranium, oil shale, and geothermal potential, and a large fraction of the existing and potential hydroelectric generating capacity.¹

This awareness of the energy crisis will be followed by reawakening to the importance of copper (75 percent in the Region) and molybdenum (90 percent in the Region) to the industrial and computer age, phosphate (60 percent in the Region) and potash (85 percent in the Region) to food production by intensified agriculture, and the criticality of many of the other, approximately 80, minerals found in the Region.²

The concern for the energy situation has interrupted, usurped, or at least confused, the developing concern for adverse environmental impact and upset ecological balance resulting from energy resource development. The "crisis" terminology for the energy dilemma was precipitated in part by tension in the Mid East and the Arab Nations' decisions on oil exports and pricing and aggravated by the years of preceding indecision relative to petroleum import quotas and environmental controls which virtually stopped construction of pipelines, refineries, and many power plants.

The net result of these extraregional factors is that low sulphur coal and oil shale and, in the longer term, geothermal energy in the Region, formerly not considered economically recoverable are, almost overnight, attractive to investment from sources of capital which are largely

outside the Region. The intraregional characteristics, particularly the sparsity of water resources and related geographic, and climatic factors assure extremely long recovery time from surface disturbances resulting from mining operations of this type. Almost a quarter of the area (including the Dakotas) contains coal deposits with the fraction approaching half of Wyoming, Montana, and North Dakota.³

Without the energy crisis, the Region was experiencing explosive growth in urban areas, new communities, second homes, ski slope development, individual recreational activity, industrial operations and accompanying water and power, construction mineral, waste disposal, and transportation problems.

Most of the oil shale is concentrated in the Green River Formation. Much less area is involved than for the coal formations but the environmental impact on the water of the Colorado River and the tremendous amounts of spent shale (one to two tons per barrel of oil) is potentially extensive.⁴

In summary, the urgency of the situation arises from the complexity of the interrelationship of the following factors in combination and the attendant possibility of decisions being made by default or without foreseeing irreversible consequences.

1. The demand for and abundance of mineral and energy resources of the Region.
2. The requirement for capital flow into the Region for the development of these (and other) resources.
3. The requirements for large amounts of water in extraction and processing operations.
4. The relatively low employment in mining and energy activities (capital intensive).
5. The amenities of the Region for living and recreation.
6. The long recovery time from any surface disturbance.
7. Rapid rate of change, growth, and development.
8. The long-term impact on the balance of agricultural, recreational and urban land use which may result from decisions based on short-range requirements for minerals.

It is questionable that one of the options open to the Region is whether or not to mine critically needed resources. Without debating this question it is certainly in order for the Region to be concerned about the impact of mining operations if and when they take place. How the mining operations are performed, what long-term use is planned for the area being mined, and what compensation the Region should receive in return for the depletion of non-renewable resources are pertinent questions.

It is apparent that if coal and shale oil are extensively developed in the Rocky Mountain and adjoining High Plains

Region for use elsewhere in the United States, there is danger of our Region developing a neo-colonial status relative the rest of the country unless prior planning is undertaken to prevent it and if environmental costs are not counted. Thus the question arises, what political and economic arrangements can be realistically developed to avoid the neo-colonial status? Furthermore, the less apparent and potentially much expanded future scope of the problem, relating all mineral resources to the total regional picture, should be anticipated with action appropriately designed to prevent the development of future crises.

In order that action be "appropriately designed" a comprehensive view of the mineral and energy situation pertaining to the Region is urgently needed. The urgency of this need applies to certain areas of research which must be accomplished before facts and interrelationships can be defined. This report attempts to identify these research needs.

1.2 The Mineral and Energy Situation

1.2.1 Summary

The Rocky Mountain Region of the United States is endowed with enormous mineral and energy resources which are being increasingly sought to supply the Region's and Nation's burgeoning needs. However, the increased extraction and processing of these resources will entail heavy financial, socioeconomic, and environmental burdens as well as many economic and social benefits. Greatly expanded research, policy development, and planning by the public and private sectors will be required over the next several decades to cope with the resource-environment dilemma. Solutions to both the immediate and long-term aspects of the Region's mineral, energy, and environmental problems should be sought by accelerated actions at the state, regional and national levels.

Between 80 and 90 minerals are mined in the Region. In order to give comprehensible dimensions to the scope of the problem, 20 minerals have been selected as illustrations of various criteria of present or potential significance. Table 1 is a partially completed summary of pertinent characteristics of these selected minerals. One of the problems which became apparent in preparing this table was the difficulty in finding data identified as pertinent (as well as inconsistency in data found). The empty spaces in the table call attention to this fact. Also note that in columns 4 and 5 much of the information is not regional. In no case was all of the data available in one reference. In most but not all cases the data are known to be available. No attempt was made to complete this table in detail since its major purpose is to illustrate the approach to selection. Such data should be developed for all minerals mined in the Region as a first step in determining appropriate action.

TABLE 1. Minerals with Significant Relationships to Rocky Mountain and Associated High Plains Region

1 Mineral	2 Major Need	3 Where Found in Region**	4 Resources (except as noted)			
			World	Domestic	World	Domestic
Coal	Fuel for Generation of electricity	All states--primarily Mont. & Wyo.		>90%		6%
Oil Shale	Fuel--Petrochemicals	Wyo., Utah, Colo (Green River formation)	66%	100% Recoverable at current prices		NA
Crude Oil: Natural Gas	Fuel: Petrochemical: Nitrogen Fixation	New Mex., Wyo., Utah, Mont., Colo, West Texas	US: 01% World: 7% Gas: 20%	Approx. 25%	US Cons.: 01% Oil: 30% NG: 49%	US Prod.: 01% Oil: 71% NG: 95%
Uranium	Nuclear Power Plant Fuel	All states	US: 17% World: 100%	US: 50% World: 100%		
Geothermal Energy	Electric Power Generation	Potentially all states	8-10% incl Alaska	90% incl Alaska	29% Calif.	0
Phosphates	Fertilizer	Mont., Idaho, Wyo., Utah		60%		11%
Sulfur	50% to fertilizers	West Texas		50% West Tex.		44% Texas
Potash	Fertilizer	New Mex., Utah		--		86% (N. Mex.) US Prod. Cons.: 40%
Ammonia (from Natural gas or coal)	Nitrogen Fertilizers	Natural gas West Texas New Mexico	See Natural Gas	U.S. World 25% (1971)	US Prod. Cons.: 10% (1971)	
Selenium	Numerous including glass, xerography, photoelectric cells. Anticipated large demand animal nutrition (forage crops)	With copper and coal	23%		21%	

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5 Consumption or Production History	6 Yield of Mineral in Ore	7 Mining Method	8 Processing Methods	9 Water Demand	10 Energy Demand	11 First Order Environmental Impacts	12 Remarks
Regional (1000 tons) 1960-11, 194 1970-28, 920 1971-34, 073	--	Primarily strip	Electric generation Gasification Liquefaction	9.5-17-10 ³ acre ft/yr 20-30-10 ³ acre ft/yr 250-10 ³ cuft/day 20-65-10 ³ acre ft/yr 10 ³ bbl/day	3 BTU Coal 1 BTU Electricity	Surface Disturb- ances	2/3 of 71 production used in region--primarily electrical generation
NA	10-15 gal/ ton shale to 25-40	Open pit Strip Underground-- conventional Underground-- retort		10-20-10 ³ acre/ ft/yr per 100-10 ³ bbl/day	280 MM kWh/yr per 100,000 bbl/day	Surface disturb- ances; Tailings disposal Leaching; Water pollution; Salinity--Colo- rado River	Made economical by current energy situation + import embargo
NG Oil 1940- 2.8 7.6 1950- 6.2 13.5 1960-12.7 23.2 1970 22 29 (10 ³ BTU)	High Varies	Deep wells	Refining little in region	220 gal/bbl Sec- ondary recovery oil. 2400 gal/ MMCF Nat'l gas liquid production		Slight in produc- tion. Pipel. nos are major con- cern	Except for New Mex., Wyo. & West Texas region imports. Gas is running out--will lead to coal gasification plants.
U.S.--10 ³ short tons, U.S.: 1960-19, 1966- 10, 1970-13	0.25	Surface + Underground	Milling Refinement Enrichment	570 gal/ton ore	2500 megawatts typical enrich- ment plant	Surface Disturb- ance	Will become much more significant fuel for generation of electrical energy. Thorium currently not produced in quantity.
USA 0-300 mega- watts 1960-1972	NA See Column 8	Deep well	Electric generation	Potential producer		Thermal pollution Water pollution (mineralization subsidence)	
U.S. Production Phosphate Rock 1000's Long tons 1990 511 1900 1490 1910 2856 1920 4103 1930 3927 1940 4002 1950 10253 1960 14202 1970 38739	20-25% (24% clas- sified as reserves)	Strip	Flotation Acidulation	175-320 gal/ton acid grade product	10.4-10 ³ BTU/ ton (35 to make sulfur and sulfuric acid)	Slime disposal & contaminant Surface Disturb- ances Air Pollution-- SO ₂ & fluorides	Important trace minerals are lost in processing. Phosphate rock production not keeping up with demand. Sales of a large part of the Florida production to Russia increases demand for pro- duction of our Rocky Mountain deposits.
U.S. Production Long tons 1940 3-10 ³ 1950 6-10 ³ 1960 6.7-10 ³ 1970 9.6-10 ³	High in deposits mentioned low as by- product of petroleum, gas, coal	73% mined by Frasch process	Deep well Superheated water Melts sulfur (Frasch Process)	4-50 tons/ton sulfur	See Phosphates 6000 cuft Natural Gas/ton used in mining (Frasch process)	Air quality	Byproduct from fossil fuel burning could substantially alter picture. Currently an oversupply.
Tons U.S. Cons. 1950 1.25-10 ³ 1970 5.5-10 ³	20-25% K ₂ O Equiv.	Underground & evaporative brine ponds	Flotation	40-50,000 gal per ton KCl	Nat. Fuel Surface Gas Oil Disturbance cuft gal /ton /ton Muriate 1090 129 Sulfate 4173 96		Canada major low price supply. Saskatchewan in 1970 established conser- vation regulations--makes our reserves more attract- ive. Less than 20 years in New Mex at present rate
US Production 1000's tons 62 4450 63 5126 64 5895 65 6655 66 8079 67 9435 68 10115 69 9986 70 11014 71 11299 72 11753 73 12024	--	Deep Wells for gas strip for coal	Steam reform- ing	79,000 gal/ton (20°F temp rise)	38-10 ³ cuft Natural gas/ton NH ₃ feedstock 4-10 ³ BTU energy/ton		As natural gas supplies are depleted return to manufacture from coal will be necessary to sustain level of fertili- zation
657,000 lbs 1971 (63% of con- sumption)	1 lb/ton copper (see copper)	With copper	Byproduct of electrolytic refining of copper			See copper	Selenium burned with coal estimated ore: 10 times annual consumption.

*This table is primarily to illustrate approach to selection of minerals not to give complete information.
Unfilled vacancies, particularly on water and energy, may be unfilled because of difficulty in locating
information within time constraints of this report's preparation rather than unavailability of data.
**See Appendix for maps showing where minerals are found.

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STRUCTURAL METALS

MISCELLANEOUS

1	2	3	4	5	6	7		
Mineral	Major Need	Where Found in Region	Resources in Region (except as noted)	Production World Domestic	Consumption or Production History	Yield of Mineral in Pre Mining Method		
Copper	Electr. wire Brass & Copper Tub- ing, etc.	Ariz. (over 50% U.S.) Utah, New Mex., Wyo., Idaho, Colo., Mont.	90% ?	93%	Tons 0.5 Prod 1900 0.3-10 ⁶ 1950 93-10 ⁶ 1970 1.75-10 ⁶ 1972 1.5-10 ⁶ World 6.6-10 ⁶	1900 4% 1910 1.88% 1950 .89% 1970 .6% Present .4% & less	Open Pit	
Molybdenum	Steel alloys Stainless * tool	Colo., New Mex. and with copper (see copper)	100%	75% Mo mines 25% w/ copper	World Prod. 1b/yr 1906 .1-10 ⁶ 1932 .3-10 ⁶ 1937 .30-10 ⁶ 1943 .30-10 ⁶ 1946-49 .20-10 ⁶ 1972 .200-10 ⁶	Mo mine 1 to .5% with copper .015 to 1%	Block saving Open Pit	
Aluminum	Metal	Idaho, Wyo	See remarks		U.S. 1000's short tons metal 1921 37 1941 920 1944 1450 1961 2113 1971 3925	Alumina/ Bauxite-55% Alumina-37% Alumina-57% Alumina 35% Aluminum in oil shale 1.5% (equi- valent to Al-Dawson- ite)	Bauxite not mined in region See remarks	
Chromium	Alloy steel plate	Montana- Stillwater	--	80% 0 0 See remarks	Consumption (1000's tons) See text 1940 600 1950 800 1960 1100 1970 1400	15 to 64 cr. O ₂	Layered deposits Surface and underground	
Construction Stone (limestone, Dolomite, etc.)	Limestone & Dolomite is 75% of crushed stone. 65% of each used in construction chiefly roads, 15% Portland cement.	All states	Mined near population centers		Construction Stone-10 ⁶ tons U.S. Production 1949 222 1959 141 1969 961	Crushed Rock 100% Cement 60%	Quarrying	
Bentonite	Drilling muds Iron Foundry Petroleum refinery	Wyoming, Mont., Colo., Nev., Utah	-50%	100%	Tons 1950 1-10 ⁶ 1960 1.7-10 ⁶ 1970 2.7-10 ⁶		Strip	
Sodium Carbonate (soda ash) Na ₂ CO ₃	47% glass manufacture	Wyoming (Trona depo- sits) w/ Calif. Trona 43% of pro- duction- Mont., Colo., Nevada	Most of Trona	70%	33%	1000's of tons Natural Sources (Trona) 1948 289 1959 735 1961 806 1965 1400 1971 2878 Solvay Process 4600 down to 4100 in 20 yrs	Trona-high Natcolite in oil shale 12-26%	Surface and underground
Helium	Refrigerant inert gas	All states with natural gas			97%	10 ⁴ cu ft (solid) U.S. 1950 81 1960 380 1965 642 1970 650 (see remarks)	0.3% in natural gas	with natural gas
Gold*	Jewelry 60% Industry (Electronics) 29% Dentistry 11%	Ariz., Colo., Nev., Utah Nev. 2 of 3 largest mines	8% (U.S.)	2.6%	66% incl So. Dak. 94%	U.S. Consumption 10 ⁶ ounces 1955 1.30 1960 3.0 1965 5.1 1970 6.0	0.3 oz/ton in gold mines. Also coproduct of copper	Underground Open Pit with copper

*Lead, silver, iron and zinc would be appropriate inclusions but would not add materially to illustrative purpose of this table.

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8 Processing Methods	9 Water Demand	10 Energy Demand	11 First Order Environmental Impacts	12 Remarks
Smelting Electrolytic Refining	?	4 to 10-10 ⁶ BTU/ton	SO ₂ from smelting, surface disturbance	Pits intensive local but not extensive in impact
Roasting Smelting	?	4 to 10-10 ⁶ BTU/ton	Surface dis- turbances, SO ₂ to airshed roasting process	--
Calcining pro- cess to obtain alumina Electrolytic reduction to obtain aluminum	?	Calcining-- high Electrolytic 10 kWh/ton	Red mud waste (slimes) Dust fumes (fluorides) Surface water electrolytic SO ₂ from electric generation re- cycling (disposal)	Alumina found in Utah, also source of potash, bauxite with oil shale. Processing plants for bauxite will be attracted to region because of high energy use. Currently almost 100% imported--Jamaica, Surinam
Milling Smelting	?		Large dumps and tailings in Stillwater River valley if mined	45% imported from Soviet Union. Remainder South Africa and Turkey Stillwater mine not competitive today's prices, only produced during WWI, WWII, Korea
Crushing Calcining	372 gal/ton 1.55 lb water/ lb cement	6.91-10 ⁶ BTU/ton cement .4 tons coal/ton cement	Surface Disturb- ance Dust	A few miles of hauling by truck exceeds cost of stone @ mine
	?	3000 cu ft gas/ton	Surface Disturb- ance water quality	May occur over coal deposits-- unknown at present. More land leased, more surface disturb- ance and more spills in Montana for Bentonite than for coal
	1000 gal/ton soda ash 1610 gal/ton ore	Shortage of fuel gas for Trona processing in 1972 & 1973. 6500 cu ft gas/ton. 6.5-10 ⁶ BTU/ton 100 kWh/ton	Surface Disturb- ance water quality (fluorides)	Solvay process has severe environmental impact
--	--	--	--	When not recovered from natural gas lost to atmosphere. 1440 cuft produced for stockpile in 1972. Total in storage 35,600 million cuft est.
			Localized surface disturbance tailings	26% of consumption reclaimed from scrap. South Africa produces 2/3 of world output.

The minerals were selected on the basis of urgency of need for four applications: energy, fertilizer, structural metals, and miscellaneous; and criteria based on one or more of the following: recent history of production or consumption, yield, mining method, processing method, water demand, energy demand, and first order environmental impact. First order impact is defined as the impact on land, water, or air (as opposed to second order on plants, animal, or people). All minerals are either found in the Region in relatively large proportions or there is a reason for processing plants to be located in the Region.

In general the minerals are characterized by some but not necessarily all of the following: recent history of rapid increase in rate of consumption (see Table 2 where data from column 5 of Table 1 are summarized); low yield; surface or strip mining or large tailings disposal; processing near mining operation with waste disposal problems; high water and/or energy demand; and relatively severe environmental impact. Some of the minerals were selected for inclusion for reasons not immediately obvious (e.g. aluminum, chromium, ammonia, selenium, helium, and sulfur) which will be summarized below. All minerals are in one way or another important to our survival and lifestyle.

Table 2
Growth Rates of Production or Consumption
of Minerals Emphasized in this Report
(Based on Data in Column 5 of Table 1)

Mineral	Base Data	% Growth Per Year	Period	Doubling Time Years
Coal	Regional Production	10 16	60-70 70-71	7.3 4.7
Oil Shale		--	--	--
Crude Oil	National Consumption	4.6	40-70	15.4
Natural Gas	National Consumption	7	40-70	10.2
Uranium	National Production	39	50-60	2.1
	National Production	11	60-66	--
	National Production	7	66-70	10.2
Geothermal	National Production	Started 1960 to 300 megawatts	72	
Phosphate	National Production	7	50-70	10.2
Sulfur	National Production	4	40-70	17.7
Potash	National Production	7.7	50-70	9.3
Ammonia	National Production	10	62-72	7.3
Selenium		--	--	--
Copper	National Production	3.2	50-70	22
Molybdenum	World Production	5.6	37-72	12.7
Aluminum	National Production	4.7 (Retail; almost no are produced in U.S.)	43-63	15.1
Chromium	National Consumption	3.5	40-70	20.2
Limestone/Dolomite	National Production	7	49-69	10.2
Bentonite	National Production	9.1	50-70	13.9
Sodium Carbonate	National Production	13.6	61-71	5.4
Helium	National Consumption	11	50-70	6.6
Gold	National Consumption	11	55-70	6.6

The following section highlights those characteristics of each mineral which led to its selection as illustrative of significant or potentially significant problems.

1.2.2 Energy Minerals

A. OIL AND NATURAL GAS

The fact that the demand for fuels has outrun domestic supplies of oil and natural gas and that satisfaction of domestic demands at current rates of growth would lead to importation of over 50 percent of our petroleum by 1980, make oil and gas the "trigger" to all problems related to other energy minerals found in greater abundance in the Rocky Mountain and associated High Plains Region. The situation is summarized as follows:

	Crude Oil (billion barrels)		Natural Gas (trillion cu. ft.)	
	World	U.S.	World	U.S.
Cumulative production through 1971	264	97	620	415
Proved Reserves	632	38	1725	279
1972 Consumption	17.5	5.7	46	22.8

Although a large fraction of the reserves of oil and gas (from conventional wells) are present in the Region, the more significant relationship to potential problems is the pressure brought to bear on the coal, shale oil, uranium, and geothermal energy resources within the Region. The possibility of extraction of gas from deep, tight formations in Colorado, Utah, and Wyoming is being explored via various gas stimulation technologies such as advanced hydrofracturing and "Plowshare" (nuclear fracturing). USAEC and several private firms are conducting experiments such as the recent Rio Blanco project in western Colorado and the proposed Wagonwheel experiment in Wyoming.

Secondary recovery operations, deeper drilling and new incentives for exploration may lead to additional production of oil and gas in the West Texas and Wyoming fields.

B. COAL

Coal resources (consisting of bituminous, sub-bituminous, and lignite) represent perhaps the most sought-after mineral in the Region due to the extremely thick coal seams, shallow overburden, low sulfur content of the coal needed to meet ambient air quality standards in electric power generation, the widening gap between domestic needs, and supplies for oil and natural gas and increased prices of Mideastern oil.

Large electric power complexes in the Four Corners area are already underway and major expansion is planned. Several other major coal-fired power generation centers have been proposed for the Region, including sites in Colorado, Arizona, Utah, New Mexico, and the Powder River Basin in Wyoming and Montana.

Another major proposed use for the Region's coal resources is that of coal gasification/liquefaction. In the gasification process, coal is converted to synthetic "natural" gas for residential and industrial applications. (The production of ammonia for fertilizers is one of the more likely significant applications discussed below). Coal liquefaction would convert coal into various hydrocarbons and "building block" materials for the petro-chemical and pharmaceutical industries. The abundance of strippable coal in the Region is an attraction to various energy-intensive processing industries (such as aluminum discussed below).

C. SHALE OIL

An estimated 1800 billion barrels of oil are contained in the Green River shale formations in Colorado, Utah, and Wyoming, in deposits averaging 15 gal/ton.* Pending successful pilot and near-commercial-scale oil shale production operations currently planned in the three-State area, this resource could be a significant factor in the Nation's oil production in the 1980-2000 period.

Constraints on shale oil production are expected to consist of economic and environmental ones. These include costs of production, energy requirements, availability of water, water quality, spent shale disposal, and esthetic costs. The timeliness of the following 50-year-old quotations illustrates the long standing concern for oil shale as a source of oil.

This volume has been written because petroleum has achieved such great importance as a concentrated fuel in American industrial life and because oil from oil shale promises in the immediate future to supplement the supplies of well petroleum, and, in the more distant future, when the supply of well petroleum gradually fails, to furnish the bulk of the oil needed.

Several points with respect to plant location must be studied by those contemplating oil shale operations. Is a sufficient supply of oil shale available and may it be mined under favorable conditions? Can the shale be readily transported to the plant site? Is the topography of the plant site suitable for arranging a logical and economical flow sheet for materials in process, and is there room for future plant expansion? Can provision be made for ample dumping space for waste materials, including spent shale,

which will amount to nearly the volume of the raw shale put through the retorts? Is there adequate water supply, and are plant wastes likely to be a nuisance to others located lower down on the drainage system? Can adequate provision be made to secure suitable living quarters and sanitation for the mine and plant workers? These and other similar problems must be given careful consideration.

The problem of water supply is, in many places, likely to be the most serious of all these problems. This is not true of many places in the Eastern States, but the situation may be serious in the West. In the western shale districts rainfall usually is sparse, and the water courses are few and widely scattered. Water may in many cases be obtained by drilling, and in other cases it is planned to divert water from the larger streams. However, irrigation is increasing in the West and the greater part of the water from many streams has been, or will be required for such projects. In each case the problem requires careful consideration, since it seems that from 150 to 250 gallons of water will be required for each ton of shale handled. (This includes the operations of retorting and refining). In addition, water may be required in mining, and large quantities must be supplied for domestic use of plant and mine labor. In many places the strictest economics in the use of water must be practiced.¹

Exact water requirements are difficult to pin down without pilot plan results. The figure is from two to three times present estimates (20,000 acre ft./year per 100,000 bbl/day plant).²

D. URANIUM*

Significant growth is expected in the Region's uranium industry over the 1975-2000 period owing to rapid expansion of the nuclear-electric power industry throughout the Nation and world. "Yellowcake" (beneficiated ore, U_3O_8) reserves of the Region are estimated at 273,000 tons in rock averaging about 22 percent U_3O_8 . This is almost 100 percent of national reserves. Currently, 19 uranium mills, most of them in the Region, have a capacity of 31,900 tons of uranium-bearing rock per day.

Prospective developments in the Region's uranium and nuclear energy industries include the following:

- (1) Uranium mining and milling -- increased exploration mining, and milling expected over the next two decades;
- (2) Uranium conversion -- new plants for conversion of

yellowcake into uranium hexafluoride (UF₆) may be built in Region;

- (3) Uranium enrichment -- plants using the gaseous diffusion process (GDP), with their large electric power requirements, may be located near coal resources; if the centrifuge process is perfected soon, the Region may not be the site for enrichment plants;¹⁰
- (4) Nuclear power plants -- Arizona and Colorado are sites for nuclear power reactors presently under construction or planned; several other Rocky Mountain sites are being considered as nuclear power plant sites for operation after 1985. Because availability of cooling water is a locational constraint, advent of direct gas turbine cycle (with its air cooling potential), using high temperature gas cooled reactor (HTGR) technology might be appropriate in the Region;
- (5) Nuclear fuel reprocessing -- plants to recycle plutonium and unused uranium may be located in western part of the Region (close to West Coast nuclear power plant sites) after 1985;
- (6) Radioactive waste management -- proposed sites for high-level radioactive waste storage/disposal in the Region are under study by USAEC. One such site is near Carlsbad, New Mexico. Presently, significant quantities of high- and intermediate-level radwastes are stored at AEC's National Reactor Testing Station in Idaho.

E. GEOTHERMAL

Although reliable reserve estimates are not presently available, it is believed that the Region contains a large fraction of the Nation's recoverable geothermal energy resources. Several Rocky Mountain States are expanding their geothermal survey activities and several geothermal exploration programs are underway by public and private interests.

It is believed that significant generation of electric energy from geothermal sources could be accomplished by 1990-2000. This is contingent upon greatly expanded research, exploration, testing, and provisions of certain incentives such as tax and depletion allowances, etc. Estimates for total generation capacity in this time frame vary by almost 2 orders of magnitude.¹¹

1.2.3 Fertilizer Minerals¹²

A. PHOSPHATES

Phosphorus is an essential nutrient in plant production. Less than 20 percent of that introduced into the soil is used in the year of application. The residual must be supplemented for sustaining high crop yields.

Projections indicate that the United States, which is the world's major supplier of phosphate fertilizers, will need to

double exports by 1975 in order to use present and planned fertilizer production capacity. The production of phosphate rock is currently not sufficient to feed this planned capacity. This will bring increasing pressure on the resources within the Region (most of them in southern Idaho) and on the use of lower grade ores.

B. SULFUR

Sulfuric acid is required in the production of phosphate fertilizers. Currently most of the sulfur is mined by the Frasch process from deposits on the Gulf Coast and in West Texas. Sulfuric acid processing plant capacity at present limits the production of phosphates.

The cost of recovery of sulfur from stack emissions in copper smelting and power generation is not competitive with the cost of mined sulfur using present ground rules. With higher energy costs (the Frasch process is energy intensive), with environmental benefits discounting part of the economic costs, and with other sources developing, such as coal gasification plants, byproduct sulfur may have a major impact on the fertilizer industry.

C. POTASH

New Mexico almost monopolizes U.S. production of potash,* the major source of potassium--another essential nutrient in plant production. However, much larger deposits exist in Canada where the rate of production is controlled by the government. Shortages of potash existed at production facilities in the fall of 1973 due to the shortage of transportation facilities (and competition with grain for the use of these facilities).

D. AMMONIA

At present ammonia production has no obvious relationship to regional problems. A brief look at history explains its presence in this report. Sixty years ago less than one percent of nitrogen fertilizers were synthetic (source was mined nitrates). Thirty years ago over half were made from synthetic ammonia using hydrogen derived from coke. Beginning in the late 1950's natural gas took over as a source of hydrogen.¹³ It is predictable that the next generation will be based on coal gasification and that the Region will become a major factor in production of one of the world's most important chemicals for nitrogen fertilizers and all other nitrogen compounds. Inorganic chemical tonnage is exceeded only by sulfuric acid in this country.¹⁴

*Utah has significant production and reserves.

E. SELENIUM^{15,16}

The present demand for selenium seems neither critical nor large and environmental impact is insignificant. However, recent studies indicate that a small amount of selenium (more than .04 parts per million) is a critical ingredient in the diet of animals, including man. More than 4 parts per million is toxic. It is estimated that an optimal nutritional level in forage crops would require 25 million pounds of selenium annually.

As noted in Table 1 this is more than 35 times 1971 production. Also note that a major source at present is from residues of copper refining and that about 8 million pounds of selenium goes "up the stacks" in coal burning per year.

Selenium is a prime candidate for a co-product or byproduct to balance costs of environmental controls to supply a possibly essential need in food production. Additives are presently legal in New Zealand.

1.2.4. Structural Metals¹⁷

A. COPPER

The combination of all factors which make a "critical" situation is present for copper. It is highly concentrated where found (Arizona, Utah, Idaho, Montana, Nevada, Wyoming), low yield (less than one percent copper in ore mined) and energy intensive in processing. Mining and processing causes environmental impacts on surface, water, and air. It is sold at prices which must be competitive in a world market. It is absolutely essential to our civilization with its maze of wiring and plumbing.

Copper is the perfect illustration of need for an interdisciplinary integrated approach to problem solution as opposed to tinkering piecemeal with parts of the problem (of which SO₂ regulations are an example).

B. MOLYBDENUM

Everything said about copper is true of molybdenum except that the critical application is different (primarily alloy steels), its rate of use is about 1.5 percent that of copper, and concentrated deposits are not as widely spread as for copper. Most molybdenum is produced in Colorado and New Mexico. Much molybdenum is mined as a byproduct of copper.

C. ALUMINUM

There are three reasons for including aluminum in this report: (1) Extraction and processing from the ore that is the most common source, bauxite (very little of which is mined in the United States), is one of the most energy-intensive processes in use. Therefore, location of these processing plants in the Region is likely. (2) Increase in energy prices will make lower yield ores found in the Region, alunite and

Dawsonite, more economically feasible. (3) One of these ores, Dawsonite, is found in oil shale and, therefore, has co-product potential.

The applications of aluminum in everyday life should be evident to everyone.

D. CHROMIUM

The major reason for including this mineral is that the only mine of significance in the USA is in the Region, and we have chosen *not* to mine it for economic reasons, except during wartime emergency. This is interesting in the light of our present situation in oil when the sources (USSR, Turkey, and South Africa) are considered. A total of 1,850,000 long tons of chromite ore has been mined in the U.S., half of which came from the Stillwater complex in Montana. This mine was active in 1915-1920, 1938-1948, and 1952-1962. Note that this total production is only 35 percent greater than 1970 consumption in the USA (see Table 1).

1.2.5 Miscellaneous

A. CONSTRUCTION STONE

The cost of hauling construction stone (as well as its counterpart sand and gravel) and its widespread distribution make everyone familiar with the applications and techniques of mining and associated environmental problems. The high consumption of water* and energy in the manufacture of Portland cement make this operation of particular concern in our Region.

B. BENTONITE

The localized impact of mining Bentonite clay (highest grade occurs in Wyoming and Montana; also mined in Mississippi) is representative of a number of similar local situations. Bentonite is strip mined, in regions where coal probably exists but is not known to exist,¹⁸ and has toxic byproducts. It is uniquely useful as a "high swelling" clay (increases in volume 15 to 20 times when wet), in drilling muds, and as a catalyst. The first shipment from Rock Creek, Wyoming was 1888.

C. SODIUM CARBONATE (SODA ASH)

"Evaporites and brines" include many of the sodium salts as well as potassium, magnesium, calcium, boron, nitrates, strontium, bromine, iodine, and chlorides.

Soda ash or sodium carbonate is notable in that the output from the trona deposits in Wyoming, which were first discovered in 1938 and first produced in 1950, has increased at a very rapid pace (see Table 2). Increasing concern with

*Dry processes are also used.

environmental problems with the previously major source--the Solvay process--and cost advantage resulted in this rapid development. Another way of saying this is that it became possible to localize all environmental problems in southwestern Wyoming (instead of in Solvay plants in the East).

Environmental problems are not of major proportions but they are there and similar to other evaporite and brine problems. A specific impact area within the Region (because of demand for evaporite and brine products) is the Great Salt Lake. This is a major source of sodium sulphate (salt cake) and magnesium.

D. Helium¹⁸

When untrapped from the earth, helium, a neutral gas with unique application, promptly leaves for the outer atmosphere. The major source has been as a byproduct of natural gas. It is under serious consideration, in liquid form, as a refrigerant for superconducting power transmission lines (boiling point: -453°F).

Almost all of the known potential sources for helium (aside from that produced with natural gas) are in the Region. The significance of this fact for future developments has not really been assessed.

E. Gold

It might be said that gold is what started it all since initial mineral exploitation in the West was for gold and silver. The "sleepers" in the gold situation is its "consumption" and its importance in the electronics industry; the fact that extremely small amounts are used per device simply makes recovery and recycling difficult, so that the gold is literally consumed. The present major uses in jewelry, monetary, and dental applications are perhaps something we can do without, or at least may rate lower than electronic applications. The facts are that it is mined at very low yields in the Region and does, locally, have considerable environmental impact. To the extent that it is a co-product of copper, it shares the expense of the copper mining impact.

1.3 Physiography of the Region

This region includes four physiographic provinces, shown in Figure 1. These are the Plains, from the northern border of Montana to the Big Bend in West Texas; the Rocky Mountains, from the northern border of Idaho to northern New Mexico; the Intermontane Plateaus, from southern Idaho and northern Nevada to central Arizona and New Mexico; and the Basin and Range areas on the western border of Nevada and the southern borders of New Mexico and Arizona.

The basins of the Great Plains area are of low relief, although some areas approach the ruggedness of the borders of the Rocky Mountain Region. Most of the coal deposits (and much of the oil and gas) are in this region. Elevations range from 1,500 to 6,000 feet.

Over 80 percent of the water in the Region comes from above 8,600 feet in the Rocky Mountain province. This part of the system is characterized by its ruggedness, with peaks higher than 13,000 feet.

Within the Intermontane and Basin and Range regions are found dry lake beds (sources of evaporites and brines--phosphates, potash, sodium salts, magnesium, etc.), metal deposits, and five basins containing strippable coal deposits (Colorado Plateau). The five basins are Uinta in Utah, San Juan in New Mexico and Colorado, Black Mesa in Arizona, Kaiparowits in Utah, and Powder River Basin in Wyoming. This part of the Region is characterized by aridity and erosion with many escarpments and mesas. Elevation ranges from 1,000 to 8,000 feet.



PHYSIOGRAPHY OF THE REGION
Figure 1

In general, the entire Region is characterized by relatively high scenic values, low timber productivity,* variable climates, high mineralization, and great topographic relief. Many environments are fragile because of varying combinations of thin soils, low ground cover, and adverse climatic conditions. They are very sensitive to human impacts and are slow to respond to corrective measures. The population of the Region is growing at a more rapid rate than the national population. Important factors in this growth may be scenic values, open space, environmental amenities, abundant mineral resources, and economic opportunities associated with these. It is tragic that population growth and change can destroy the very attributes that are responsible for this growth. This region is one of the last areas in the U.S. where it is possible for man to plan and control his environment so as to reach a balance between the quantitative and qualitative components of a total living standard.

The Region is an attraction to many visitors for touring, camping, sports, recreation, etc. It contains such national parks as Big Bend, Carlsbad Caverns, Grand Canyon, Petrified Forest, Rocky Mountain, Mesa Verde, Glacier, and Yellowstone; many national monuments and forests, and countless lake and stream fishing and camping areas. The Region contains major winter sports areas, particularly in Colorado and Utah. The southern part of the Region is a national winter vacation attraction for those who want and are able to escape the rigors of winter in other regions of the country. Recreation and tourism are year-round activities in many parts of the Region.

In addition to the development of mineral resources, speculative residential and commercial development of private land is growing at a very rapid and essentially uncontrolled rate in the Region. Whether these developments ever become populated or not, they have lasting adverse impacts on the environment and influence the future options available to land-use planners and public land managers. The relative sparsity of private land and the fact that it is often completely surrounded by public lands (or vice versa) is a key factor in the general problem. This factor also increases the complexity of the problem, since the agencies which control public land cannot, directly, control the use of private land.

If economic and population growth are allowed to continue in an uncontrolled manner, water will be accentuated as a critical, limiting factor. For example, projected private developments in the vicinity of Flagstaff, Arizona could increase the demand for water, already in short supply, by a factor of ten. Much effort has gone into obtaining federal water projects to push such limits back, while little attention has been paid to the opportunities to attain economic growth by reallocation of existing water supplies among uses.

*With possible exception of northern Idaho.

Water development projects, including watershed management practices for increased water yields, have environmental and economic impacts. For example, the proposed delivery of water from the Colorado River to a reservoir northeast of Phoenix (Granite Reef Aqueduct to Orme Reservoir) and the existing McCulloch Corporation Development of Fountain Hills (located nearby) will not only have direct impact on the environment but will have significant economic effects. Consequent increases in population, and resulting increases in recreational traffic, second home and motel development in the Mogollon Rim and White Mountain areas will expend the problem.

Much of the land in the Region is dedicated to Indian reservations. For example, the Navajo, Hopi, and Apache reservations in the Region are the largest in terms of area and Indian population in the country. They contain important mineral and recreational resources. The people have strong cultural traditions. All of these factors must be considered in intimate relationship to adjacent public and private lands.

Government proving and test grounds and military reservations attract population and commercial development and create recreational traffic. They also contribute to another factor—the large population of retirement age due to attraction for the area developed by service personnel during their tour of duty.

The Region also has a substantial length of Canadian and Mexican border. In addition to complicating localized jurisdictional control and encouraging additional tourist and recreational traffic, this presents certain problems relating to water use, as well as water and air quality for mining operations both near the border and remotely located on watersheds affecting the borders.

Although the timber resources of the Region are minor compared to those of California, the Northwest, and the southeastern States, they are, nevertheless, of economic and ecological significance.

These characteristics emphasize the complexity of the Region and the need for priority establishment in the development of an effective research program.

1.4 Land Ownership and Use

Mineral and energy resource development planning and decision making are complicated by complex patterns of public and private land ownership and management. In some states, administration and management of public lands may involve over 25 federal and 15 state agencies. Table 3 summarizes the total acreage of federal lands in the eight Rocky Mountain States plus the acreage of land withdrawn from mineral and energy development by two federal agencies. Withdrawal of lands under other institutional administrations has occurred but is highly variable, primarily because of the multiple use policy.

Table 3. Acres of Federal Land in Rocky Mountain States and
Acres of Land Specifically withdrawn by Two Federal Agencies*

State	Area of State	Total Federal Ownership	% of State	Lands of National Park Service	% of State	Lands of Dept. of Defense	% of State
Arizona	72,688,000	32,423,513	44.6	1,565,873	2.2	3,665,310	5.0
Colorado	66,485,760	24,152,057	36.3	526,601	0.8	297,475	0.4
Idaho	52,933,120	33,848,735	63.9	85,045	0.2	160,930	0.3
Montana	93,271,040	27,654,289	29.6	1,154,766	1.2	614,601	0.7
Nevada	70,264,320	60,725,334	86.4	254,358	0.4	3,146,769	4.5
New Mexico	77,766,400	26,388,272	33.9	240,738	0.9	2,772,046	3.6
Utah	52,696,960	35,060,194	66.5	561,972	1.1	1,886,065	3.6
West Texas**	65,000,000	1,500,000	2.3	1,000,000	1.5	500,000	0.8
Wyoming	62,343,040	30,059,522	48.2	2,309,609	3.7	26,325	0.0
Total	613,448,640	271,811,916	44.3	7,698,962	1.2	13,069,521	2.1

*Based on data take from *One Third of the Nation's Land*, Public Land Law Review Commission, Washington, D.C., June 1970, 342 p. + map.

**All figures approximate.

Mining patents may be filed for wilderness lands, under stipulations of the 1964 Wilderness Act, until December 31, 1983 (for minerals only, not for the land). Almost all federal minerals are managed by the Secretary of the Interior through the Bureau of Land Management.

Disputes between the U.S. Bureau of Indian Affairs and Indian Tribal Councils have confused the legal situation for mineral resources on the 32 Indian reservations within eight of the nine States. Other problems exist on private lands where numerous homestead patents were approved, but the Federal Government retained some or all of the mineral rights. Where both private and public lands are closely intermingled, as in the railroad checkerboard lands, it is inevitable that problems will develop concerning ownership and use of mineral and energy resources. Only West Texas has a preponderance of private land, with a relatively small amount in state ownership.

Overall, it seems that more problems of mineral and energy resource planning and decision making are the result of proliferation of the numbers of diverse controlling agencies rather than the specific restrictions encountered in withdrawals.

1.5 Life Cycle of Mining Regions

The energy dilemma has released a flood of articles, books, press features and TV shows which have one common ingredient that can be considered a healthy influence. This ingredient is a greatly expanded time perspective. There are two scales in this perspective, both of which should affect our actions.

The first of these might be labeled the epochal scale. This scale considers periods such as the total span of fossil fuel burning society. In an article in late 1972, Prof. Earl Cook, Dean of Geosciences at Texas A & M University, identified three phases in the future on this scale:¹⁰ the mining phase (a few decades for oil and gas, a few centuries for coal), the rock burning phase (a few centuries for nuclear fuels), and the solar phase (after 100 years). This article also contains an interesting retrospective look at China showing four periods of relative feast and famine (based on energy cycles) covering a period of 2,000 years.

In this report our immediate concern is with the mining phase and, within that phase, the life cycle in five periods: exploration, design and development, construction,

operation, and closure. These operations go beyond traditional practice in mining operations which has not included planning much beyond the period following the present activity; i.e., if exploration is successful, the next step is design and development.

These five periods constitute one stage in a three-stage time perspective. This second time scale is well within the first, epochal scale, but well beyond the scale typically considered in the past. This expanded perspective is emphasized in the description of research needs which follow. These are:

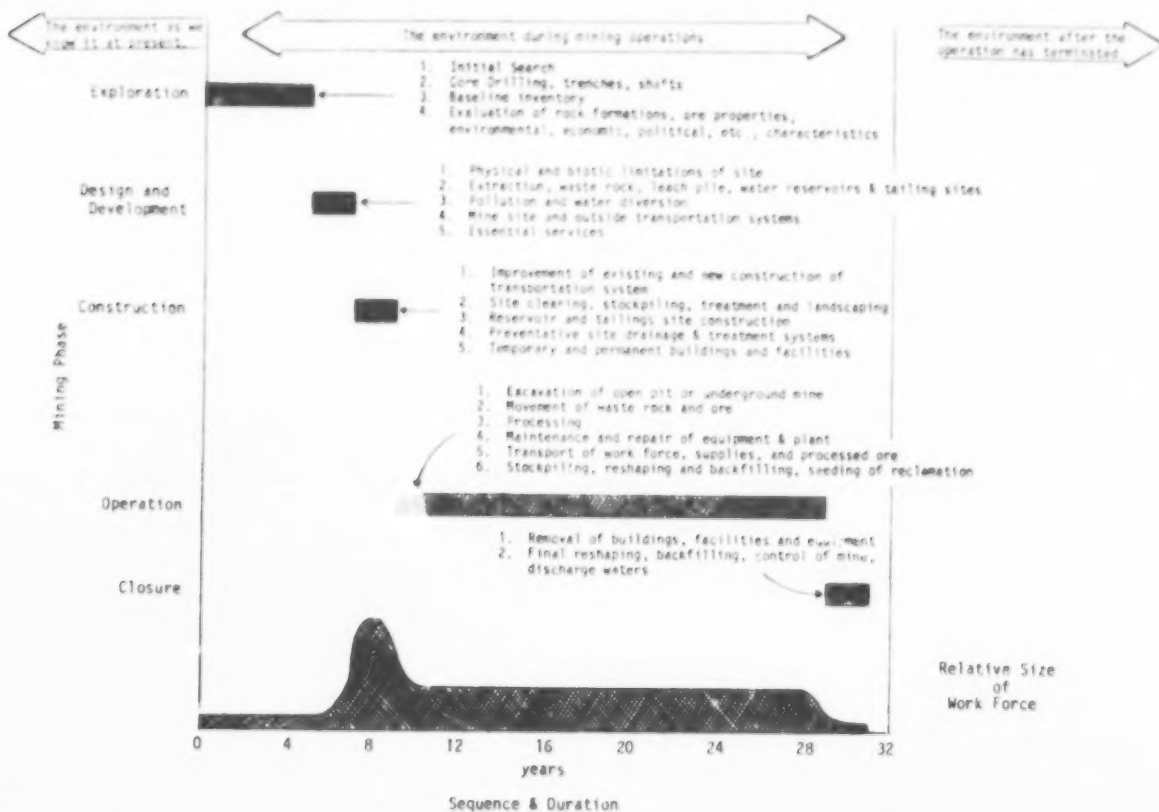
1. The environment as we know it at present,
2. The environment during mining operation,
3. The environment after the operation has terminated.

The word "environment" is used here in the broad cultural sense (physical, social, economic, etc.). In short this raises several questions. What do we have before mining operations? What do we want to have after mining operations? These two are asked as part and parcel of the question: What will we do during mining operations?

The region has examples of all periods of mining operations—several in major proportions. Strip coal and oil shale are representative of post explorative operations which are about to proceed with development, construction, and operation.* All of West Texas and eastern New Mexico are looking a few years ahead to what will happen after oil and gas run out. Bisbee, Arizona is facing a shutdown of its copper mine within months—after operating since 1877. Whether it can be as successful as Central City, Colorado in maintaining a tourist attraction remains to be seen.

There are all periods in between these extremes. There are also several miserable examples of what happens after closure, including operations stopped early in the development periods. The isolated ghost towns should serve as an example to guide thinking in a direction which avoids the "ghost region" possibility.

*Strip coal has been mined for years, but the future possibility is a greatly expanded activity with new ground rules. Much less is known about oil shale.



1.6 Criteria for Acceptable Solutions*

This section is in the report to call attention to the *fact*, not opinion, that in matters of resource development, social change, and political action a *problem cannot* be defined unless *criteria* for acceptable solutions are established. In abbreviated form this says that you must know the answer before you can define the problem. Frequent comparison of the energy and the environmental problems to the space program neglect this basic fact. The answer in the space program was clearly and concisely defined--have man on the moon and back by a certain date. With this answer given, engineers and scientists defined the problem, alternative solutions, selected among alternatives, and took action.

In the context of this section an "answer" is where we want to go--an objective or goal for action. A "solution" is a way of getting there--a method or process of change. A problem is defined by the formulation of questions which must be resolved in order for alternative solutions to be described. The concept of "truth" as the objective of activities of science--to discover truth--is replaced with the concept of "purpose" in the sense that purpose guides activities of engineering--to accomplish a purpose.

It is absolutely essential to recognize that we are addressing ourselves to *social change* not just *technological development*. The dictionary definitions of "society" all emphasize communities bound by common interests, standards, objectives, purposes, etc. This may serve to define certain social institutions, organizations, agencies, etc., but does *not* define the complexity of interacting interests, institutions, and influences which characterize existing society--including that society which is geographically included in the region of interest in this report. The range of external influences, as well as the range of internal values which affect this region, do *not* have a common base.

*This section received strong criticism and strong support in the reviews of draft copies of this report. The leader of the task force who prepared the report prepared this section and sincerely believes the criteria question to be a crucial issue. Hopefully this revised version will be responsive to critics. If the reasoning is still not clear, the writer apologizes. The personal conviction remains that this section is *fact*, not *opinion*. The task force supports this position.

The members of the task force who prepared this report fully recognize that there are alternatives to mineral exploitation in the Region: recycling, solar energy, fusion, use of other global resources, limiting growth, etc. How long these alternatives can remain open options is a basic and controversial question. As stated in section 1.1, this report attempts only to define research needs relating to mineral exploitation if this exploitation takes place. This approach is *not* intended to de-emphasize the critical importance of research directed toward development of alternatives to this exploitation, which has received and continues to receive extensive attention in the literature.

For example, we are concerned with research related to the treatment of mine tailings *if* they exist. We are not looking at research related to the alternative conditions under which they would not exist. Within this context, revegetation of mine tailings may be an acceptable treatment or "answer." Research in this case may be directed toward plant selection and development, soil treatment, or both. A solution is clearly a description of compatible plants and soil conditions. Either a plant will grow or it will not.

On the other hand, research may also be needed relative to policy and incentives. A solution is "clearly" a description of policies relative to revegetation which are acceptable to all industrial, public, and private interests and incentives which will result in behavior consistent with these policies. *But no such policies and incentives exist, and this is known before research is done.*

The facts are that "answers" relating to mineral, energy, environmental, economic, and social issues can only be fuzzily defined. More elegant words such as "imprecisely," "vaguely," or "not clearly" can be used. The more graphic term "fuzzy" is widely used in general systems theory. The concept is used to describe situations where there is indeterminacy due to vagueness rather than randomness. Lofti Zadeh introduced the concept of a fuzzy set as an *aggregate of elements with an ill-defined boundary* almost 10 years ago.¹¹ For the issues at hand it is of critical importance to recognize that policies will be fuzzy, criteria which constrain solutions will be fuzzy, and problem definition will be fuzzy. Any attempt to develop consensus on criteria among the many interests involved will be unsuccessful or, if successful, will so oversimplify the problem to make the definition useless. Russell Ackoff, a recognized authority in operations research at the University of Pennsylvania, has summed up this situation as follows:

In a real sense, problems do not exist. They are abstractions from real problems. The real situation from which they are abstracted are

messes. A mess is a system of interacting problems. Planning should be concerned with messes. Not problems."

These difficulties should not deter our enthusiasm for finding solutions to "messes" however messy they may appear. However, if their existence is not acknowledged, progress is less likely to occur than if left to random chance.

2. STATE-OF-THE-ART

2.1 State-of-the-Art Related to Regional Problems

To summarize the state-of-the-art relative to the topic of this report in all of its complexity and detail would require discussion of current activity in approximately 30 disciplines ranging from botany and chemistry to law and political science. This activity relates to at least the four categories of minerals identified in Table 1 and with variations related to the four physiographic provinces mentioned in Section 1.3. The topics would range from international relations to pronghorn antelope.

The value of such a summary in relationship to the objective of this report would be, primarily, to serve as a check list to be balanced against foreseen problems and needs for the identification of missing information. This approach is neither possible nor practical for the purpose of this project. The approach used has been to assemble a task force composed of members with sufficient collective breadth and depth of experience and education and then pose the question:

"Where are the boundaries of the state-of-the-art relative to our ability to define and cope with the problems presented by existing and potential extraction of mineral and energy resources in the Rocky Mountain Region?"

Section 4 is the task force's response to this question identifying research needs with, as they were directed, very little justification.

It is possible to identify a few sources of information which summarize certain aspects of the state-of-the-art and broad areas of missing information.

The Mining and Mineral Policy Act of 1970 resulted in the publication of two documents without which background information for this report would be very scattered. (Both of these documents were heavily used in developing Table 1.) The Mining and Mineral Policy Act states the following:



Public Law 91-631
91st Congress, 5, 719
December 31, 1970

An Act

To establish a national mining and minerals policy

86 STAT. 1878

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Mining and Minerals Policy Act of 1970".

Sec. 2. The Congress declares that it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in (1) the development of economically sound and stable domestic mining, minerals, metal and mineral reclamation industries, (2) the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security and environmental needs, (3) mining, mineral, and metallurgical research, including the use and recycling of scrap to promote the wise and efficient use of our natural and renewable mineral resources, and (4) the study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities.

For the purpose of this Act "minerals" shall include all minerals and mineral fuels including oil, gas, coal, oil shale and uranium.

It shall be the responsibility of the Secretary of the Interior to carry out this policy when exercising his authority under such programs as may be authorized by law other than this Act. For this purpose the Secretary of the Interior shall include in his annual report to the Congress a report on the state of the domestic mining, minerals, and mineral reclamation industries, including a statement of the trend in utilization and depletion of these resources, together with such recommendations for legislative programs as may be necessary to implement the policy of this Act.

Approved December 31, 1970.

Mining and Minerals Policy Act of 1970.

"Minerals."

Report to Congress.

The most useful of these documents is the *United States Mineral Resources*, Geological Survey Professional Paper 820*, published in 1973 and provides not only current information but a complete bibliography in 722 pages. The foreword by the Secretary of the Interior states the following:

As a part of our response to the Mining and Mineral Policy Act of 1970, the Geological Survey provides in this volume the first overall assessment of mineral resources since that of the President's Materials Policy Commission in 1952. It goes beyond traditional resource appraisals, which have considered mainly inventoried reserves, to examine the geologic availability of resources that will be needed in future generations. For many minerals, these appraisals are preliminary at best, for not enough is known about their origin, distribution, or the geologic environments favorable for their occurrence to assess their potential now. But at the least they represent a beginning, a take-off from which we can expect to enlarge our knowledge of our mineral-resource endowment with advancing science and exploration.

*For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Library of Congress Card No. 73-600060, and Card No. 72-622941, respectively.

The second annual report on Mining and Minerals Policy^{*} and its appendices contains a 73-page summary and 354 page status report on every mineral mined or processed in the United States.

The third edition of Chemical Process Industries (referred to in Table 1), published in 1967, can be used as a foundation for more recent information on specific processes or be found in subsequent *Chemical Engineering* magazines. Recent issues of various journals have summarized certain aspects of the problem (most in reaction to the energy crisis). Some of these are listed in the bibliography.

There are also new journals appearing on the scene, for example:

Journal of Environmental Quality (Published by a cooperative of American Society of Agronomy, Crop Science Society of American and Soil Science of America.)

Technology Assessment (Published by Gordon and Breach, Science Publishers Ltd.)

Published literature as catalogued in the usual library reference systems and government document indexes deals extensively with the geology and geography of mineral resources, methods of extraction and processing, economics of recovery and use, etc. Only very recent published literature deals with environmental and social impact. The Geological Survey professional paper 820 mentioned above has a short section labeled "Problems for Research" associated with each mineral (with one or two exceptions—oil and gas for instance). Some of these sections mention environmental problems. For example:

Because economic exploitation of molybdenum today requires that large tonnages of ore be mined and processed, large surface areas will be disturbed whether mining be done by underground methods or by open-pit methods; and because of the low mineral content of the ores, large surface areas will be needed for disposal of the residual waste materials. Molybdenum exploitation therefore is subject to the same or

similar environmental problems as any large-scale operations, whether it be strip mining of coal, stone quarrying, mining of beachsand deposits, or open-pit mining of iron, aluminum, and copper.¹⁷

The section under "copper"¹⁸ which is mined and processed by very similar techniques and in much larger quantities, says nothing relative to environmental problems.

There is a pressing need for a comprehensive and continuing effort to catalog state-of-the-art information in the broad spectrum of disciplines, relationships, and variations mentioned in the first paragraph of this section. It is generally agreed that there are five broad categories of missing information:

(1) Published information similar to that found in the references mentioned above which is specifically pertinent to the Region or even catalogued or indexed so that it can be identified with the Region. (Reports published by various agencies dealing with States or parts of the Region are numerous. For example, a 649 page report prepared for the Four Corners Regional Commission by the University of Arizona, "Minerals in the Economic Development of the Four Corners Region," has a 35 page selected bibliography. Almost all of these references are published by the industries, state agencies, special reports of legislative committees, federal agencies, research institutes and universities.¹⁹)

(2) Information relating to all aspects of plant and animal culture on arid, harsh, disrupted land, tailings, etc., resulting from mining operations. The study of agriculture has concentrated on productivity of good land.

(3) Consideration of mining as a fully integrated operation rather than a problem of maximizing rate of delivery of mineral to the market place. A British report published in September 1972 nicely summarizes this approach.¹⁸

(4) Analysis of mineral and energy costs in other products such as food²¹ and packaging.¹⁸

(5) Comprehensive regional analysis using existing and rapidly developing "modeling" techniques.

Some discussion of this last point may be in order. An example of "modeling" relating specifically to mineral resource development is given in the British report mentioned above. Input-output analysis of the Leontief variety has been applied to West Virginia in a rather extensive study.¹⁹ The same technique has been applied to Texas in a similar analysis.²⁰ The Arizona Trade-Off Model²¹

*See footnote, page II-D-15.

¹⁷Published by McGraw-Hill, Inc., 330 West 42nd St., New York, NY, (available only by paid subscription). For example, a report on copper processing in the April 16, 1973 issue.

using somewhat different approaches is in early stages of application. Forrester-type modeling (basis for *Limits of Growth*)¹⁹ needs to be applied in the direction of regional (instead of global) proportions in order to be made more relevant to environmental, social, and economic issues of presently manageable proportions. The president of IEEE Systems, Man and Cybernetics Society, Kan Chen, has commented: "The real question is perhaps not whether Forrester-type models could be validated, but how such models should be put to use."²⁰ (Note the use of "could" and "should.")

The interconnected, interactive nature of the most fundamental and complex problems of our resources, our environment and our lifestyles, *cannot* be understood or controlled without the use of some kind of models of relative complexity. We cannot even establish criteria and goals, let alone estimate consequences. The idea that these models are mathematical nonsense should be put to bed and the models put to use with the stipulation that no-nonsense practical results are expected.

The models cannot be put to practical use without extensive valid quantitative information, readily accessible, on the Region (item 1 above). However, it cannot be over-emphasized that the essence of our problem is controlling the future and that analyzing the past or present is only to this end. The degree to which these models can be used to engineer a future in accordance with our desires is based not entirely on information about the present situation but must include quantitatively valid information relating future actions to future results.

2.2 State-of-the-Art Related to Extraregional Influences

In order for the Region to make valid assessments and decisions relative to regional problems and research, the state-of-the-art in all areas pertinent to the regional situation must be known and understood. For example: whether the Region's policy was to develop shale oil as an economic boon or not to develop shale oil as an environmental calamity, knowledge of the status of solar energy and nuclear fusion would be essential to a wise decision. This is without regard to the degree of knowledge or ignorance relative to the costs of extracting oil from shale, its requirements for water, and its environmental impact based on factors *within* the Region. No matter how wrong or right this information might be it cannot be used as a basis for judgment without knowing the status of the pertinent extraregional information.

There is need, therefore, for regional decision makers to know or to have the advice of people knowledgeable of the status of the myriad of extraregional activities which relate to regional objectives. This includes not only the status of mining, mineral, and energy technology throughout the United States and the rest of the world, but the status of transportation facilities, port facilities, regulations and regulatory bodies, continually increasing needs for minerals and energy, international agreements and tensions, and the modes of interaction among all of these factors and many others. Our resources and the complex machinery for obtaining and using them are so basic to modern society that it is difficult to identify anything not related to their development.

It follows that almost any decision made by government, industry, or any other institution which leads to action will be felt throughout our system. Consequences of this in recent months are entirely too much in evidence.

This need for knowledge on the state-of-the-art relative to extraregional influences should not be confused with the need to do research relative to regional objectives. The research needs of practical necessity, must be identified with the selfish interests of the Region. On the other hand, when it appears that exploitation of the Region is being used as a crutch to evade serious consideration of potentially viable alternatives, the region must be able to recognize and challenge this approach on solid ground.

3. ON-GOING ACTIVITIES

The proliferation of activities which relate to the problem adds to the urgency of the situation. These activities (including the Rocky Mountain Environmental Research Project), are separately conceived, and more or less uncoordinated with other similar efforts. A very cursory review of them shows that the majority are "current crisis" oriented. This does an injustice to a strong undercurrent of activity which seeks not to react to crises or avoid crises, but to eliminate the word from the vocabulary by broadening perspectives, deepening understanding, and tempering knowledge with judgment (a synonym for wisdom) in making decisions.

A few of the agencies and pertinent projects are listed below:

Agency	Project
Eisenhower Consortium (9 universities in 5 states plus Rocky Mountain Forest & Range Experiment Station)	This project (RMER) Several small studies
The Institute of Ecology (Lists among founders 65 universities & other institutions)	This project(RMER) Environmental Impact Assessment Project
Northern Great Plains Resource Program, Dept. of the Interior	Development of Coal Deposits in the area
Rocky Mountain Center on Environment (with TIE and Committee on Future Environments)	Energy Policy: Issues and Responses, 8 states
Western Interstate Nuclear Board (12 States AEC type coordinating agency)	Just completed Energy Resource Development for the West
U.S. Dept. of Agriculture Forest Service	Surface Environment and Mining (SEAM) (Reclamation of strip mined areas)
WEST Associates (Association of Western power companies)	Task Force on Water Task Force on Air
WSCC (Western System Coordinating Council--also power companies)	Committee on Environment
EPRI (Electric Power Research Institute, Hdqtrs., Palo Alto, CA, began operation in 1973)	Energy systems environment and conservation divisional committee Also has division for coal-related research
Environmental Protection Agency (3 hdqtrs. involved in Region--Denver, San Francisco, Dallas)	Several projects
U.S. Dept. of the Interior Bureau of Land Management	Energy Materials Recommendation System (EMARS)
Federation of Rocky Mountain States	Coordinates among Executive Branches
State Governments	Energy Coordinators; Environmental Quality Councils; Advisory Commissions on Environment, etc.
State Universities	All universities involved in variety of projects; some centrally coordinated, some not.
Thorne Ecological Institute	
Battelle Columbus Laboratories	Study environmental impact and prepare environmental impact studies
State Mining Associates (One in every state representing industry in various activities)	Numerous studies
Ford Foundation	Energy Policy Project

Agency	Project
Colorado Dept. of Natural Resources	Four studies -- water, revegetation and rehabilitation, environmental inventory and impact, regional impact and land-use planning for the oil shale development in northwest Colorado. (jointly funded by Fed. Gov't., State Gov't. and industry) 2 years, \$735,000 budget, done by subcontractors (USGS, CSU, Thorne, and THK Assoc., DRI, & Brown, Bickest, Coddling.
Colorado Plateau Environmental Advisory Council	
National Fish and Wildlife Lab	
Denver Wildlife Research Center U.S. Dept. of the Interior	Effects of coal and oil shale development on wildlife ecology.

Among these activities, communications seem most effective in the organizations of the power industry, no doubt because their systems are literally connected and because they have common objectives.

In addition to the above, numerous ad-hoc groups are organized by citizen groups, government agencies, and industrial and commercial organizations for the purpose of investigating a subject and preparing a report. These are frequently not listed in any library information service, and in many cases they are excellent, well-documented sources of information.

This list is by no means complete, and the obvious forthcoming statement, "It is beyond the scope of this report..." is not very helpful.

The list is sufficiently complete to emphasize that regional objectives would be served by some centralized point of reference, a secretariat type office that is continuously up to date on the status of various activities--not a control--not a clearing house--just informed and up to date.

4. RESEARCH NEEDS

4.1 Framework for Research Needs

The abundance and diversity of mineral and energy resources in the Region, the competing land and water uses, and the extreme sensitivity of much of the area to environmental impact make the categorization of research needs very complex. The interactive nature of the problems,

on the other hand, make any list of isolated research projects of limited value and, in some respects, misleading. The following "framework" is an attempt to provide a key to this interaction. It indicates relationships which could be lost in the following discussion defining research needs.

The terminology used in the column headings should be self-explanatory except for the words "operational" and "functional." The word "operational" means one of the steps used in bringing a mineral from its natural setting to the market place. Thus for any given mineral all of the operational activities in this column must be performed if the mineral is brought to useful form. Note that activities from *exploration* through *closure* are classified as operations emphasizing the total view of the mining life cycle.

The word "function" applies to activities which may be common to several operations. For example, water treatment might be involved in all of the seven operations listed.

In the past research on "operations," in general, has been viewed in the context of maximizing productivity where productivity was related to delivery of mineral to the market place at minimum cost. Treatment of tailings, for example, was "non-productive." Operations have been looked upon as mineral specific--even mine specific. Research on "functions" presenting problems common to the industry has largely been left to the suppliers of equipment; e.g., bulldozers, responding to *their* marketplace--the mining industry. Overburden removal is common to many mining industries. The commonality is recognized by the manufacturer of bulldozers who, incidentally, may also provide features applicable to road building and housing projects.

Table 5. FRAMEWORK FOR IDENTIFICATION OF RESEARCH NEEDS

I Mineral Category ^a	II Operational Activity	III Functional Activity	IV Nature of Impact	V Intraregional Characteristics	VI Institutional Arrangements	VII Policy	VIII Extraregional Influences
1. Energy a. Coal b. Oil Shale c. Crude Oil: Natural Gas d. Uranium e. Geothermal Energy	1. Exploration a. Access b. Evaluation of potential c. Quantification relative to other needs, environmental factors, etc. 2. Development a. Access b. Construction c. Utilities d. Housing 3. Production and Extraction a. Deep ground b. Surface open pit & strip 4. Initial Processing a. Milling b. Smelting c. Refining 5. Transportation a. Ore b. Processed minerals c. Electricity d. Pipelines 6. Intermediate Stage & Final Processing (Manufacturing) a. Copper cable manufacture b. Uranium fuel elements c. Conversion to electrical energy d. Uranium extraction & reduction 7. Closure a. Construction removal b. Topsoil replacement & contouring c. Revegetation d. Irrigation	1. Water Treatment a. Diversion b. Evaporation c. Heating d. Salination e. Purification 2. Control of Atmosphere contaminants a. Dust b. Gases c. Noise 3. Waste Disposal a. Tailings b. Acid water 4. Surface Disturbance a. Topsoil removal b. Vegetation c. Access roads 5. Reclamation of Disturbed Land a. Revegetation b. Reshaping	1. Economic a. Capital flow b. Competing demands c. Commerce d. Employment e. Taxation 2. Social a. Migration b. Community growth 3. Environmental a. Water quality b. Hydrologic c. Wild life d. Flora e. Aesthetics 4. Competitive Resource Uses (land, water and air) a. Recreational b. Agricultural c. Urban d. Wilderness 5. Occupational a. Safety, Health b. Skills needed c. Duration of need	1. Geologic a. Mineral resources b. Water resources c. Soil mechanics d. Hydrology 2. Climatic a. Rain & snow b. Fall prediction c. Micro-meteorology 3. Geographic a. Desert lands b. Foothill lands c. Ponderosa & mountain shrub d. Grassland prairie e. Riparian 4. Demographic a. Few urban centers b. Mining towns c. Farm & ranch d. Tourist e. Retirement f. Reservation 5. Life Styles a. Outdoor recreation b. Casual living	1. Government a. Federal b. Regional c. State d. County & City 2. Gov't Control Mechanisms a. Taxes b. Tax incentives/breaks c. Use taxes d. Severance taxes e. Zoning f. Tax rebates g. Regulations h. Penalties i. Subsidies j. Judicial relief 3. Academic a. Universities b. Consortia of universities 4. Industrial & Commercial a. Development Corp b. Power companies c. Retail stores 5. Non-Profit Research Organizations 6. Interest Groups a. Indian b. Military c. Environmental d. Cultural e. Religious f. Business g. Labor h. Agriculture 7. Political Parties 8. International a. Argentina b. Canada	1. Objective oriented (cost benefit, aggregate social utility) 2. Noncommittal (no articulated goal, heterogeneous social utility) 3. Rational Action (perfect knowledge + articulated goals) 4. Organizational Process (traditional) reluctant to change 5. Bureaucratic Politics (various conceptions of national, organizational and personal goals)	1. Population movement 2. Capital investment 3. Demands for minerals + energy 4. Industrial development 5. Tourism 6. International Trade

^aMinerals listed in each category are representative only. There are between 80-90 minerals in a complete listing for all categories of those mined in the region.

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The interactive nature of problems, mentioned above, is brought out by mentioning that, if the treatment of tailings is considered non-productive, it may be for one or more of several reasons. The impact has not been felt (Column IV--they are hidden--not in your backyard). The impact does not seriously affect or is not noticeable in the natural environment (Column V--perhaps true in the Amazon jungle but not true in this region). Profit is not affected by regulations, tariffs, taxes, or incentives (Column VI--the rules of the game do not make tailings treatment profitable). Policies are based on traditional practice (Column VII--but we have always done it that way). Competition in the international market sets prices (Column VIII--how can we stay in business when the rules of our game are not the same as the rules in South Africa and South America)?

Research has been variously categorized as pure, basic, applied, long range, short range, scientific, engineering, etc. In any given audience the variety of meanings attached to these words invariably leads to confusions. To avoid this confusion we will be arbitrarily specific and identify six categories of research effort entirely in the context of the framework being discussed here. These are as follows:

1. **Single Item Research** related to a single item in a column. For example: "Study of the physiology of range plants to understand their requirements and adaptations" (related to item 5a in Column III).

2. **Intra-Column Research** relating to two or more items in the same column. For example: Bentonite and coal might be produced from a single mining operation. More land is now disturbed in Montana from mining Bentonite than from mining coal. Research is needed to determine where deposits coexist. There are many examples of byproduct and coproduct possibilities in Column I. It should be noted that invariably these examples lead immediately to research related to items in other columns such as processing, geologic characteristics, and water treatment.

3. **Inter-Column Research** relating items in two or more columns. There are many obvious examples of this (perhaps because the columns were the basis for construction of the framework). An example is the hydrology of tailings and the relationship to water quality.

4. **Single Thread Research** related to a single sequence of relationships proceeding from one column to the next through all columns. For example, strip mining of coal causes devegetation which affects wild life (i.e., pronghorn antelope) whose habitat is grassland prairie and, in the case of antelope, a tourist attraction under the jurisdiction of Wyoming.

5. **Multiple Thread Research** related to single items in one or more columns and a multiplicity of items in other

columns. For example: What will be the total capital flow into the Region for intermediate stage processing plants (coal gasification, uranium enrichment, aluminum reduction, power generation, etc.) during the next 25 years? This question relates to the neocolonial status mentioned earlier. This is a type of research relating to "data base".

6. **Multiple Thread Intra-Column Research** relating to interactions along several single threads and among several items within single column. This provides the comprehensive analytical framework which ultimately relates everything to everything else in the framework shown. Most of the examples of these "models" focus on the words in column IV--"economic," "social," "environmental," etc. When such models contain the competing regional interests under study by other task forces on this project (urban development, second home, recreation, timber harvesting, etc.), the entire mineral and energy framework becomes a "sub"-framework.

The greatest research need relates to these last items, 5 and 6: improvement of both the data base and the comprehensive analytical framework.

There is an additional level of complexity which is more often than not given insufficient attention in the complex research efforts and technology assessment projects. This involves the composition and structuring of the research team which is to define the problem solution. This activity in a successful effort is inseparable from the definition of comprehensive analytical framework. It provides the answer to the question: "What organizations, institutions, and relationships are needed to get a regional perception of ourselves?"

Underlying all of this framework, which clearly indicates the regional and extraregional (or spatial) scope of the problem, is the additional need for concern for the distribution of effects in time discussed in Section 1.2.4. This not only suggests that the initial plan avoid the "ghost town" which characterizes mining activities of the old west and provide for land use after mining activities have ceased, but that concern for future generations should be a part of the picture.

The "need" for research is based on two criteria: (1) Information is needed for an identified end use; (e.g., how to recondition tailings to support plant life). (2) Information is not known; (there is no experience related to growing plants on tailings). It may seem evident that these criteria are easily established and applied without a great deal of judgment. It is, however, true that much important knowledge is available because a researcher applied only the second criterion. (I don't know so I will find out). It is further true that an identified end use does not eliminate logical steps in the expansion of knowledge necessary to "finding out."

In addition to criteria based on end use and lack of knowledge, there are degrees of urgency based on short- or long-range utility and the relative immediacy of the problem (end use). These will be discussed further in connection with priorities (section 5).

It soon becomes apparent that there could be infinite combinations of interactions and time durations to be considered in identifying research needs. The following finite list is finite only because arbitrary but hopefully justifiable judgments have been made that some interactions are more significant in end use than others *and* that more needs to be known about these interactions before appropriate future actions can be decided. The latter immediately implies value judgments relative to future actions. Neither justification nor value judgments are given to support the stated needs. However, including the end use criterion in stating a research need implies that the research is perceived in relation to the economic, social, environmental, or ecological system (not just as an unexplored area of knowledge).

The headings for the following six sections are the headings for Columns II through VII in the "framework." This is based on the *point of entry* into the framework and does not necessarily restrict the research to the first or second category discussed above (single item or intracolumn).

Research needs are set apart from discussion and numbered sequentially through sections 4.2 through 4.8.

Extraregional influences are conditioning factors on all the research and cannot be ignored. The task force felt strongly that opening up this area as a *subject* for research was tantamount to requiring definition of the global research needs. For example, alternatives to oil shale exploitation include Siberian LNG (negotiation with the USSR), Arabian oil (settlement of the Mideast tension), gasoline rationing, solar energy, and nuclear fusion. Thus Column VIII is in the framework to emphasize that the Region is not an isolated entity.

Section 4.8 will discuss some of the methodology and examples of research needs in the fifth and sixth category described above (modeling of complex interactive situations).

4.2 Research Needs Related to Operational Activity

1. Improvement of existing exploration methods and development of new techniques. Basic questions are:

- a. How to evaluate the mineral potential of an area; i.e., what factors are important? How can important factors be quantified? Are there better methods to obtain these factors than geochemistry and geophysics?

- b. How to compare mineral and energy needs with other competitive needs. (Standard value for cost-benefit comparison.) Improved lines of communication to industry would help.

Discussion: There are estimates that less than one of each 100 anomalies drilled or excavated in the exploratory phase of mining are ever productive (Commission on Mining and the Environment, 1972). All too often, unnecessary and irreparable damage occurs during this mining phase. Spring flows are modified by seismic explosions; indiscriminate movement of drilling and heavy equipment obliterate vegetation and initiate serious erosion; and drill lubricant and cooling materials pollute water courses.

2. Explore processes for in situ leaching of ore bodies as alternatives to conventional mining methods and associated problems such as waste disposal and smelting. Basic questions are:

- a. What types of ore bodies is it possible to leach?
- b. What is the chemistry involved in leaching different minerals?
- c. What are the means to fracture an ore body prior to leaching?
- d. How can the movement of leaching fluids through the ore body be controlled?
- e. What are the potential effects on ground waters?

Discussion: There are essentially two types of mining operations used to extract minerals from the earth: underground operations and surface operations including open pit and strip mining. Each has different yet somewhat related effects on the natural environment. These effects are caused by the actual mining operation of waste extracted as the mineral is obtained.

3. Improve present or obtain new methods to acquire the maximum ore recovery possible from the different types of mining methods. At this time some mining methods leave 40-60 percent of the ore in the ground. Ore recovery could be improved research to obtain:

- a. Better and more efficient means of supporting the roof in underground operations.
- b. Better understanding of rock reaction to the mining or tunneling operation.
- c. Better methods of excavating rock and ore.
- d. Better machinery to accomplish items a, b, and c.

4. Improve or develop new metallurgical processes and methods to increase the recovery of primary minerals sought and/or reduce environmental impact.

- a. Obtain better or alternative means to the pyrometallurgical process.
- b. Improve the existing processes used to remove and dispose of SO₂ gas and other products.

Discussion: The location of processing plants near mining operations expands considerably the variety and complexity of environmental effects associated with (as opposed to caused by) mining operations. The choice of transportation system is related to and a part of the choice of location for processing plants. Both choices are constrained by the availability of water and energy.

5. Improve or develop new methods of recovery of the associated or secondary minerals.

- a. Recovery of polluting secondary minerals (such as sulfur) to balance costs of environmental control.
- b. Retention of secondary minerals desired in final product to improve product (e.g., iron, copper, manganese, molybdenum, and zinc are removed from phosphate and added later to fertilizer compounds).
- c. Improve profitability of low grade ores.

6. Investigate alternative design features which reduce or eliminate movement hazards for wildlife and domestic animals across or under surface service facilities; i.e., pipelines, conveyer belts, roads, railroads, and open water aqueducts, tailing impoundments, etc. Basic questions are:

- a. What design features of overhead bridges, open machinery underpasses, tunnel underpasses, etc., which are consistent with space, location, and cost limitations will facilitate the travels of wildlife and domestic animals
- b. How long does it take for tailing sites to develop the capability to permit safe surface travel by animals?
- c. What types of tailing fence or animal excluding devices are most effective and require minimal construction and maintenance expenditures?

Discussion: It should be noted that in many areas the technology is available to solve environmental problems. Applied research or the application of the technology is thus required. In some cases it is not known what questions to ask, therefore, the proper technology cannot be intelligently selected for application.

7. Expanded joint efforts of industry and regional academic institutions in specific energy related processes with potential for reducing environmental impact. For example:

- a. Coal gasification/liqefaction processes.
- b. Geothermal energy extraction methods.
- c. In situ processes for coal gasification, copper mining, shale oil recovery, etc.
- d. Solar energy for space heating/cooling and electric power.
- e. Nuclear energy systems with minimum water or dry cooling requirements (e.g., gas turbine cycle reactor).

8. Develop fully integrated approaches to planning mining operations which begin with understanding the natural limitations of the area and leads to solution of reclamation and land-use problems which will occur after the actual ore recovery operation is finished. These would include the methods of design, location, construction, operation, and closure of mineral extraction sites, with attention to trade-offs in extraction methods, milling, processing, techniques, and transportation systems. Basic questions are:

- a. What questions should be asked during the mineral exploration phase which would provide input for problem solution during the future reclamation and land-use planning?
- b. What factors are important for land-use planning that could be obtained during the mineral exploration phase?
- c. What are the possible land-use alternatives for reclamation of the different types of mining operations?
- d. What type of regulatory agency should control and provide inspection for the entire operations?
- e. What type of systems for handling materials should be designed to support the mechanical mining machine; e.g., to segregate overburden and leave best soil on top?
- f. What type of equipment should be designed for working, planting, and maintaining reclaimed mining areas?

Discussion: As emphasized earlier in the discussion of the "Framework for Identification of Research Needs," there is need to recognize waste treatment, mine closure, and preparation for subsequent land use as an integral part of the mining operation--not "non-profitable part" but an essential and integral part which is considered by mine operators and their customers as a legitimate cost of operations.

4.3 Research Needs Related to Functional Activity

9. Develop understanding and methods for control of acid water pumped from underground mining operations. Basic questions are:

- a. How to treat the water to neutralize the acid?
- b. What is the hydrologic process involved in leaching?
- c. What is the chemistry of the leaching process?

Discussion: In connection with deep or underground mining operations, acid water results from leaching of the surrounding rock mass as the ground water is pumped from the mine. This water is destructive to plant life. Hydrologic and chemical processes are not fully understood.

10. Develop understanding and methods for control of tailing ponds and piles. The following information is required:

a. Hydrology of tailing ponds and spoil piles to determine the quality and quantity of water movement and how contaminants enter the hydrologic system of an area.

b. Physical properties of tailing piles necessary to ensure proper structural design and construction of such piles.

c. Methods for removal of solids from water, in particular the very fine material (colloids) such as are found in the slime resulting from phosphate.

d. Alternative uses for tailing ponds such as incorporations with sewage disposal systems.

e. Other uses for tailings such as roadway aggregate, etc.

Discussion: Tailing ponds and piles from the mining operations are also a source of contaminants and potential hazard from land slides or dam breakage to the surface water in an area. Information is sparse on physical (structural) as well as chemical and hydrological characteristics.

11. Investigate practices of overburden removal and disposal in order to improve the quality and develop quantitative information on cause and effect relationships to resulting erosion, surface water chemistry and hydrology, ground aquifers, and physical appearance of mines and spoils.

Discussion: There are many problems associated with open pit and/or strip mining which are not adequately understood. These include wind and water erosion associated with or resulting from removal and disposition of overburden; effects of rejection, diversion or pollution of surface water; the interruption of pollution of ground water aquifers and deterioration of physical appearance of mines and spoils from the standpoint of esthetics.

12. Increase the store of knowledge generally related to reclamation of harsh arid areas characteristic of the Region. Basic information is needed as follows:

a. Determine if, how, and where reclamation can proceed, and what timetable and what landscape character will be possible where reclamation can be successful.

b. An empirical foundation of experience of the kind that can only result from many field trials and continuity of program.

c. Approaches specific to the terrain characteristics (instead of merely applying traditional farming practices).

Discussion: There are few examples of successful reclamation of mined lands in the Rocky Mountain Region. Related research has largely been in agriculture or on the improvement of slightly disturbed or undisturbed range lands and under selected conditions. Mining often occurs under physical and climatic conditions which are very harsh as regards plant establishment and growth. The effects of

open pit and/or strip mining need to be precisely characterized in order that appropriate agricultural practices can be defined.

13. Development of basic information on soil characteristics as follows:

a. Determine and perhaps bracket the ranges of physical and chemical properties of existing spoils in the Region.

b. Identify weathering processes, determine rates of soil development on spoil materials, and identify ways to influence these processes and rates.

c. Develop methods for reestablishing the soil biota which were lost in the surface disturbance and which are needed in soil development and in support of vegetation.

Discussion: Certain needed basic knowledge of soils, vegetation, climatology, and hydrology is missing. Of utmost importance is the fact that disturbed land reclamation research in the past has had very little continuity. Extensive research done in the East is of limited value.²⁴ Even in the eastern U.S. only single short-term projects have been funded, often for a master's degree problem. There has been no hard funding for continuing research, and so it has been stop-and-go with little opportunity to expand on past work.

14. Identify basic characteristics of vegetation suitable for reclamation in the Region. Basic information is needed on:

a. The physiology of plant species which are candidates for reclamation programs so as to understand their requirements and adaptabilities.

b. Breeding programs both to increase the utility of adapted species and to increase the number of useful species. Allied with this is a need to make introductions and evaluations of species which may enhance range production.

c. Propagation methods which will reasonably assure successful plant establishment.

15. Increase efficiency of water improvement for reclamation by improving understanding of relationship between local climatic and hydrological conditions, large and small scale terrain characteristics and the use of directed water movement, and mulches to reduce surface evaporation.

16. Develop and test over adequate periods of time and in realistic field situations management practices which are directly applicable to reclamation and continuing production of reclaimed lands. These field trial should include investigation of:

a. Planting methods and timing.

b. Fertilizers and irrigation. These may be site specific.

c. Methods for control of weeds.

d. Control of animals; since recently reclaimed areas may be green oases, they can attract animals which will destroy the planting.

e. The economic impact of different levels of application of each of the above.

Discussion: Some model projects need to be established where everything from initial design on through are executed with the best knowledge and experience available.

4.4 Research Needs Related to the Nature of Impact

17. Define the total impact of using public land for mining or withdrawing it from mining. What is the potential ability of the U.S. to maintain viable domestic sources of mineral raw materials in the light of alternative approaches?

a. In terms of current and future national and regional needs and priorities, where does the current and future mineral supply fit relative to the other uses and products from the public lands?

b. How does single-use classification/withdrawal of large tracts of land compare to the multiple-use land management concept?

c. How many and what size single-use classifications are justified and needed to adequately serve the purposes intended?

d. What management flexibility is desirable to assure their continued beneficial use?

e. How much wilderness area and mining area and of what sizes can be *objectively* justified in light of the management constraints inherent to the Wilderness Act and the 1872 mining law?

Discussion: It is generally accepted fact that the Nation is facing a critical shortage in many strategic mineral raw materials such as fuels, fertilizer, and metals. Evidence of this has been well documented by the Secretary of the Interior. It is also generally recognized by industry and many resource-oriented elements of government that the Nation's public lands, including the continental shelf, contain the last remaining areas in which to search for hitherto unknown mineral deposits. Prospects of success are thought to be highly favorable. The Public Land Law Review Commission studied and reported on this question in 1970. Most of these lands lie in the western States and, except Alaska, within the Rocky Mountain Environmental Research Project's scope of concern.

Yet most of the federal public land management agencies, such as the Forest Service and the Bureau of Land Management, are pursuing a high-priority program of selective land withdrawals from mining and most other uses. These withdrawals are primarily for single-use purposes which are usually recreation-oriented, and are often undertaken without sufficient investigation of minerals potential in the withdrawn lands.

18. Development of a flexible process to compensate owners of private property located in areas of critical concern when such land classification deprives such property owners of a beneficial use of such property. Questions are:

a. Who should be entitled to compensation for a wipeout?

b. Should the landowner reap the full benefit of the windfall?

c. If speculative value is decreased, is this an appropriation which requires payment of just compensation?

d. Who pays for fraudulent activities of government resulting from noncompensable police power regulations (down zoning to lower future land values in anticipation of public acquisition has been held unconstitutional)?

Discussion: Under our present system of land use regulations we distinguish between police power actions and eminent domain actions. Police power actions must face the test of being involved to protect the public health, safety, and welfare and the action must be taken in accordance with provisions found in a comprehensive plan. Recent court decisions have expanded considerably what falls within the purview of health, safety, and welfare. Provided the action is not ruled to be confiscatory; i.e., no physical taking occurs and reasonable use of the property is permitted, no payment of compensation is required. If, however, property is required for a valid public purpose, the state invokes the power of eminent domain and is thereby required to pay just compensation for the property. What constitutes just compensation, however, is a complex set of factors grounded upon a value established if the property were sold to a willing buyer by a willing seller under no duress.

The actions of public agencies have considerable impact on private land values. Some can lead to windfalls, other to wipeouts, depending upon the specific circumstances. Changes in planning and zoning, designation of an area as a critical ecological area, or decisions to locate public facilities can increase or decrease considerably the speculative value of property.

19. Development of regional and subregional quantitative guidelines for identifying and planning for social needs based on known and projected mineral resource development projects. This should include:

a. Work force projections (for both construction and operational phase).

b. Projected spatial distribution of population, based on concentration of minerals.

c. Definition of needs for increased utilities and services.

d. Procedures for disposing of solid and liquid wastes.

e. Food and fibre requirements.

f. Requirements for delivery systems for educational and other social services.

g. Definition of potentials for post-extraction economic base activities.

h. Provision for energy requirements for enlarged communities.

i. Anticipation of social stress associated with the nature of the community and source of employment.

j. Projection of political and institutional responses required in order to avoid disparities in time and place of revenues and services.

Discussion: The past history of large scale resource development activity suggests very definite spatial and behavioral patterns will occur while operations are in progress.

Unlike the frontier era when the opening of a new territory or the discovery of a valuable resource in a virtual wilderness led to a vast influx of primarily unmarried workers and fortune seekers, the present day acceleration of mineral extraction will occur in an area at least sparsely settled with a network of basic social institutions and services. Changes in community equilibrium and dynamics will occur. The magnitude in some areas may be major in scope; e.g., eastern Montana.

Direct employment in mining (as in agriculture) is small relative to manufacturing and service industries. It is likely, because of the energy availability, that processing and manufacturing will accompany the development of mineral resources. A possibility for construction of 30 to 50 large plants (power, gasification, uranium enrichment, and metal processing) within the Region can be identified. During the construction phase, 3,000 to 6,000 people may be employed, followed by 500 to 1,500 in the operational phase.

The influx of new workers and then families can be absorbed in three ways: expansion of existing communities, creation of temporary (mobile home) communities near the resource extraction site, or the development of entirely new communities. In any event, there are obvious situations and implications which are inadequately understood and where technical guidelines are needed for effective planning.

20. Development of quantitative information on the use of water by various mining operations. This should include:

a. Inventory of total quantity of water needed for specific mining operations (assuming no recycles planned and projected on a regional and subregional basis).

b. Identification of alternative processing techniques with emphasis on water consumption (including recycling).

c. Quantification of the effects of specific operations on the quality of water (assuming no treatment).

d. Development of methods, where they do not exist, for treatment of water to prevent or eliminate adverse effects.

e. Quantify effects on flow and recharge of associated aquifers.

f. Quantify effects of groundwater changes on adjacent and distant surface water supplies.

Discussion: Within this Region arid conditions prevail and in too many areas every drop of water is committed and in some cases over-committed. Depletion of supplies, disruption of flow, and loss of water quality in those areas would have a disastrous influence on the entire environment.

21. Develop and test water desalting process and systems for those locations subject to salinity induced by natural causes and by various mining and energy production operations. This should include determination of the feasibility of dual-purpose power generation/desalting complexes wherever potential for such opportunities exists.

22. Investigation of several aspects related to geothermal energy production such as:

a. Methods for locating exactly the source of geothermal energy at depth with minimum surface disturbance.

b. The control of water quality.

c. Possible noise pollution.

d. Possible subsidence of large areas.

e. ReInjection of water to reheat.

f. Possibility of creating seismic activity.

g. Various uses of the different types of geothermal deposits (other than power generation).

23. Reduction or elimination of atmospheric mobility of radioactive dusts from ore stockpiles, toxic trace elements in coal or in formations associated with other mineral bodies, and emissions from processing plants.

24. Investigation of effects on natural vegetation (as opposed to cultivated agricultural vegetation) indigenous to areas with existing mining operations or with mining potential. This effort should have sufficient continuity of effort to determine effects of long-term buildup. Areas for investigation include:

a. Gradual long-term buildup of impact of heavy metals near operations such as copper mines and smelters.

b. Modification of drainage patterns.

c. Fluorides, salts, acid drainage.

d. Gradual changes in acidity due to SO₂ atmospheric presence.

e. Determination of relative significance of specific natural plant life as producer part of the ecosystem (is it really needed?).

25. Long-term monitoring of the physiological and behavioral responses of selected wildlife to the effects of mining at representative sites.

a. Identify wildlife (and plants) which may serve as important early warning indicators of subtle environ-

mental changes adverse to the life support system for humans.

b. Specifically identify which species of wildlife can be an important component in the deliberations determining if, where, and how extraction of mineral and energy resources can be reconciled with societal needs and environmental limitations.

c. Investigation of impact of operational and functional uses of water on aquatic habitats (stream, lake, pond) and design of appropriate management practices.

Discussion: Wildlife includes all non-domesticated game and non-game species of mammals, birds, reptiles, amphibian, fishes, and invertebrates (protozoans, mollusks, crustaceans, insects, spiders, etc.). Greater emphasis must be given to the basic role of wildlife in the environmental systems upon which man's survival depends (beyond the usual emphasis on values of recreation, esthetics, and economics).

26. Projection of the kinds of trade-offs which must result from competitive uses: urban, agricultural, mining, processing, and manufacturing needs for limited water and land resources.

27. Continuing investigation of occupational safety and health aspects of mining operations such as "black lung," silicosis, asbestosis, radon and gamma radiation exposure in uranium mining and processing, ventilation, hazard protection, and rescue methods.

Discussion: In general, recent concern over environmental impact has been reactive rather than anticipative. The obvious future prospects for development in the Region should guide the initiation of research effort *now* rather than waiting for the "emergency" to arise at some future time. Unfortunately, geothermal energy is perhaps the only candidate for anticipative activity since the large scale stripping of coal and development of oil shale deposits are underway or imminent.

4.5 Research Needs Related to Intraregional Characteristics

28. Development of comprehensive baseline inventory of existing information on natural biophysical, social, economic, institutional, and cultural characteristics of the Region. This should include:

- a. That physical and biotic information which is based on comparable sampling collection and analytical methodologies (see 29).
- b. Qualitative indices for evaluating and classifying landscapes.
- c. Private land ownership data.
- d. Economic externalities of private land generated by various management schemes on public land.
- e. Recreation-tourism sites.

f. Travel dynamics for outdoor recreation and tourism.

g. Reward systems associated with various forms of outdoor recreation.

Discussion: Data on regional characteristics is classified in many forms. The normal convention is to distinguish between natural biophysical, social, economic, institutional, and cultural. Quantitative data is generally readily available from governmental agencies charged with specific responsibilities and/or programs. Data describing processes, operations, and the like are often available from universities, reports of special study task forces, commissions, or panels. Information on cultural values, life styles, perceptions, and response mechanisms is by far the most limiting area of a regional quantitative-qualitative characterization.

Information describing the major natural social and economic units and systems throughout the Region has been collected, analyzed, and published in various formats by a plethora of public and private agencies for many years. It seems reasonable therefore to assume that substantial data are already available, and we should seek to discover what it is we have and in what form it is available prior to proposing any costly and perhaps excessive duplicative data collection and assimilation ventures. There is no regional data framework which identifies what we have, who is collecting the information, in what condition the information is available, and most important to the pursuit of the objectives of research consortia such as this, what data are urgently needed or will be needed and are not presently being collected. Equally important in the planning of research and action-oriented programs and strategies is the knowledge of the scope of administrative and/or program responsibility of public, quasi-public, and private agencies and organizations.

29. Establish a program of uniform and comparable sampling, collection, and analytical methodologies in order to update, extend, and improve existing inventory on physical and biotic information such as:

- a. Location and characteristics of mineral and energy resources.
- b. Trace element distribution.
- c. Water resources.
- d. Soil resources.
- e. Major airsheds.
- f. Vegetation resources.
- g. Unstable landscapes.
- h. Wildlife resources.
- i. Patterns of land use.

30. Identify and, where possible, quantify significant interactive relationships among intraregional characteristics including:

- a. Geologic.
- b. Climatic.
- c. Geographic.
- d. Demographic.
- e. Life styles.

(see Column V of Framework). It should be emphasized that this is a step beyond and therefore depends upon the existence of the data system described in item 28 above. It leads to definition of a regional *system* and *system dynamics* as opposed to the *components* of the system in *static* relationships.

4.6 Research Needs Related to Institutions and Institutional Arrangements

Discussion: The general objective of research in this area is to determine the institutional arrangements best suited to bring appropriate regional influence upon decisions relating to mineral and energy use in the Rocky Mountain area upon which substantial agreement exists within the Region. Since it is not likely that only one institutional arrangement will suffice to obtain such a goal, the objective should be to determine the best mix of institutional arrangements.

31. Identify the relative advantages and disadvantages of providing funds to defray or pay entirely social and environmental costs of mineral and energy development (assuming an agreed-upon system for determining such costs). The alternatives should include:

- a. Severance taxes.
- b. Other taxes; i.e., excess profits, second home, recreational, value added.
- c. Lease payments (on state and federal land).
- d. Bond posted by developer.
- e. Regulations and penalties.

The basic questions are: What is the proper mix of these approaches? How should funds be collected and distributed when several States and the Federal Government are parties to development? Which organizations should receive the funds generated, and what guidelines should apply to the expenditure? How to set the level of the assessment (tax, lease, bond, penalty)?

Discussion: In theory the ability of the political sub-divisions in the Region, possibly even including a regional authority of some type, to levy taxes upon the mineral and energy resources taken from the Region may offer opportunities to direct mineral and energy use along regionally desired paths, and to generate funds with which to ameliorate both the environmental and social problems caused by the increased mineral and energy usage. Clearly there must be compromise between that which is sufficient to defray or pay entirely the social and environmental costs of mineral and energy development, and that which is not so

high as to deprive the Nation of needed resources from the region. Two famous references to taxes from the Supreme Court are appropriate in this context: "The power to tax is the power to destroy," and "With taxes I buy civilization."

32. Investigate desirability of establishing regional economic assessment capability (independent of federal and industrial organizations) with the objective of determination of taxation and leasing levels and regulatory practices (relative to economic aspects of environmental impact).

33. Investigate the desirability of establishing regional technology assessment capability (independent of federal and industrial organizations) with the objective of determining regulatory practice (relative to technical aspects of environmental impact) and feasibility of technological alternatives to regional resource exploitation.

34. Investigate and develop positive incentive approaches with the objective of balance between productivity and environmental quality. Questions are:

- a. What continuing incentives should be maintained in our society to assure a reliable and acceptable supply of fuels and mineral raw materials from domestic sources? (See the Mining and Minerals Policy Act of 1970, pg. II-D-15.)
- b. What kind of incentives can be created or promoted--economic and otherwise--to encourage acceptable environmental performance by:
 - the public generally,
 - users of the land,
 - industrialists including the minerals industries,
 - builders and developers,
 - governmental agencies, including the military.

Discussion: Most economists and philosophers agree that well structured, stable freedom and incentives are prerequisite to the encouragement and maintenance of man's productivity. Throughout the development of the current environmental movement there is consistent and continuing demand to *control, prohibit, regulate, and require* certain performance related to the environment. This is a negative concept in which one group proposes or attempts forcibly to control or limit the freedoms of another. Throughout the history of our country, the most acceptable and timely performance in any pursuit has been attained at lowest cost when suitable, positive incentives existed for such performance.

35 Determine the extent to which excessive regulatory requirements issued by multiplicity of political jurisdictions inhibit the process of bringing minerals and energy to the consuming public. The objective is to identify the type of regulatory structure which will function the best in our society in order to accomplish acceptable levels of environmental performance at minimum cost, in terms of time and money, to those affected.

Discussion: Regulatory agencies, state and federal, together with those concerned with public land management, have developed voluminous regulations dealing with land use and environmental issues such as air and water pollution. Although individual sets of regulations may be reasonable when standing alone, they frequently overlap or conflict with other regulations and regulatory bodies. The impact of this condition has been particularly severe on the fuel and minerals industries. A new minerals operation of any significant magnitude will require a minimum of two years time to obtain the necessary permits, licenses, approvals, bonds, etc., that are currently required.

36. Evaluate and compare the aggregation of recent experiences with state-level land use management, including 13 years of experience in Hawaii, in the context of experimentation and testing. The object would be to identify (or determine whether or not these can be identified):

- a. Regional attitudes and values towards the basic concept of private property.
- b. Tolerance limits of various populations to impose certain levels of restraint on the activities of the land commodity market.
- c. Regional judicial attitudes as determined from analysis of cases and opinions dealing with closely allied situations.
- d. Elements of other legal systems and property systems which should be studied and evaluated in terms of how they might be used in order to facilitate the more complete development of regional resources while still affording a reasonable level of independence and freedom to individual land owners, albeit decision makers.

Discussion: An alternative to conventional land-use controls such as zoning is the concept of land-use guidance system. This approach in essence provides flexible policy guidelines to implement density limits based on the ecologically determined capability and suitability of the land resource base. Coupled with such devices as programmed control over utility extensions, systems capacity limits, and taxation schemes, the land-use guidance systems avoid the sterile patterns of conventional zone districts. Traditionally, use of the regulatory power over land has been the sole jurisdiction of local government. More recently States have taken this power unto themselves in response to situations which extend beyond the effective grasp of local jurisdiction. Following the guidance provided in the American Law Institute Model Land Development Code, one or a combination of four approaches are in operation. These are statewide systems, management of critical areas, management according to functional criteria, and management in unmanaged areas. In a recent significant decision, the court has recognized the interrelationships which occur within complex ecosystems, the subsequent public harm which can result if certain actions

serve to modify or violently disrupt the equilibrium of the system, and the associated public values developing throughout our socioeconomic and political system (Wisconsin: *Just v. Marinette County* 201 N.W. 2nd 761). As the concept of a viable public trust becomes more recognized in our administrative judicial system of check and balance, it will become more difficult for public administrators, legislators, and special interest groups, regardless of motives, to make irreversible decisions pertaining to the use of public resources without full disclosure to the public and with public approval.

37. Determine whether interstate legislative interaction would add a useful dimension to mineral and energy policy deliberation, and how such legislative interaction could be established if concluded to have merit. (Regional political cooperation on mineral and energy matters has been at the level of the executive branch of state government, and not among the state legislatures.)

38. Investigate legal and jurisdictional questions of ownership and control with the objective of anticipating problems and conflicts which may impede development of needed mineral resources. For example:

- a. The question of developing coal under homesteaded lands (surface rights vs. mineral rights).
- b. The question of ownership of geothermal resources underlying private lands.
- c. Jurisdictional conflicts between state governments and Indian reservations; e.g., can a State impose water quality or surface mining regulations on Indian reservations if those operations have impacts outside the reservation?

39. Identify and determine approaches to resolution of potential areas of international conflict. For example:

- a. In what resource decision making should the Mexicans or Canadians be included (e.g., water planning)?
- b. What institutional changes need to be made to take into account transboundary environmental considerations involving U.S. and Mexico or Canada?
- c. What will be the impact of specific mining activities on U.S.-Mexican treaty obligations under 1944 Colorado River Treaty?

40. Studies toward development of possible multiple-use "energy-agri-industrial" centers which might aid in conservation of resources via various symbiotic relationships among industries (e.g., coupling of energy-intensive processes such as electric power plants, coal gasification, and other facilities; use of reject heat from power plants in desalination, warm water irrigation, etc.).

41. Determine the capabilities required and organizational structure suitable for government institutions needed

to supervise fully integrated mining operations from exploratory and development phase through closure. Since long range commitments may be made in the exploratory development phase, emphasis should be placed on mechanics of supervision during this period.

42. Investigate alternative institutional structures for evaluating and making decisions relative to power plant siting. The range of questions include:

- a. Will the watershed support the proposed power plant?
- b. Has adequate consideration been given to the agri-industrial plant concept which reduces waste of resources?
- c. Will the area selected support(b): (Additional population, water demands, industrial effluents, etc.)
- d. Would location of the plant in a municipal area (transporting fuel to the plant) make (b) possible?
- e. Are there particular environmental constraints on the area selected?

4.7 Research Needs Related to Policy

43. Identify regional objectives with aggregate social utility to the populations of the Region and/or identify subregions for which such objectives exist. Define regional and/or subregional policies relative to mineral and energy resources consistent with these objectives. These objectives and policies should be designed to give positive direction which avoids the following possible consequences:

- a. Boom and bust cycles.
- b. Neo-colonial status.
- c. Deterioration of regional environmental attributes (through uncontrolled resource extraction).
- d. Regional parochialism (anti-resource extraction which fails to recognize national and global needs).

Discussion: Our area of the United States faces several challenges stemming from the imminent acceleration of development of our mineral and energy resources. Understanding these challenges, (in this case, challenges to the environmental and social quality of the Region), helps to shape research strategy and set priorities for goal accomplishment. For example, this region of the Nation has experienced "boom and bust" times before, and the relics of those past days are not particularly pleasant. The ghost towns, abandoned mines, roads, slag piles, and degraded streams and lakes amply attest to the "get rich and get out" philosophy which abounded in the Region at a time when it was generally thought there would always be plenty of land for everybody, and little saving had to be undertaken. The prevention of another "boom and bust" cycle would generally be accepted as a supportable goal.

Furthermore, the Region should be on guard against the danger that developments such as oil shale and coal will cause the Region to fall into a neo-colonial status relative to the rest of the Nation. The term neo-colonial status is used to suggest a circumstance in which the Region's energy resources are removed for use elsewhere leaving both environmental and social problems to be solved without benefit of wealth which has been removed.

44. Inventory and categorize public and private entities currently influential (passively or actively) in policy making relative to resource/environmental issues. The categorization should display the range of heterogeneity of social utility in terms of perspectives, attitudes, and goals relative to mineral and energy resources (U-Chart analysis). The degree to which heterogeneity is absent will help identify aggregate social utility, mentioned in 41 above.

45. Determine the desirability for the establishment of authoritative entities (such as the Port of New York Authority) for the purpose of dealing with the policy, control, decision making, negotiation with the Federal Government, etc., which deal with regions (such as the Green River Oil Shale Formation) crossing state lines. This might include:

- a. Expansion of the powers of existing agencies such as Western Interstate Nuclear Board.
- b. Examination of the rationale and procedures of operation of existing unique situations such as the Navajo reservation.
- c. Examination and perhaps challenging of the boundaries of federal regional organizations such as EPA, Forest Service, Park Service, etc.

46. Develop methods for determining public concern and interest (the unorganized mass of citizens as opposed to large, relatively well-funded organized groups). For example:

- a. Determine the utility of the Forest Service, National Park Service, and BLM public hearing programs.
- b. Test the utility of a public opinion "survey research center" (such as the one at the University of Michigan).

Discussion: There are two basic dimensions of policy. One relates to the origin of the policy: the assumption on which it was based and the perspective used in its formulation. See column 7 of the Framework." The other relates to the result of policy formulation (sometimes called the U-Chart). "this is the dimension which ranges from liberal to conservative, etc.

Policy research is, at best, subject to a variety of interpretations. It is significant, and in support of the need for research on policy, that when the advisory committee on this project meets, the complete range of both the above

dimensions are obviously operating in the same room at the same time.

4.8 Research Needs Involving Comprehensive Interactive System Approaches

47. Develop a comprehensive and usable information retrieval system which enables the projection of basic requirements (intra- and extra-regional) related to developments of regional resources and interacting among these developments. This system supplements those described in 28 and 29 and should provide prompt answers to such questions as:

- a. Total capital flow requirements for construction of a given number of processing plants for various purposes.
- b. Transportation needs for given quantities of resource extraction.
- c. Requirements and availability of various skills needed for projected construction activity.
- d. Amount of water required for a proposed activity available in a proposed locality and for what purposes unavailable water is committed.
- e. Energy requirements for projected developments.
- f. Status of extra-regional research activities which relate to regional decisions.
- g. Who knows the answers to these and similar questions? (This implies and emphasizes a "people based" system aided and abetted by computer-based or other varieties of storage and retrieval but primarily dependent on the dynamic information available from people aware of what is going on, where information is, and, most important, who know other people who are perhaps more aware.)

48. Apply modeling techniques to synthesize, design, and determine optimum among alternative future patterns of growth (as opposed to analysing existing situations). Boundary conditions on the models should emphasize realistic constraints on the rate of flow, mobility and availability of water, material, energy, and people and associated environmental and economic factors. This should include the appropriate modification and application of such techniques as input-output transactions, analysis (Leontief variety), growth and equilibrium projection (Forrester type), trade-off models, etc., with almost exclusive emphasis on model-using as opposed to model methodology development.

49. Identify subregional areas for which reasonably well-defined boundaries can be quantified for application of various techniques of system analysis, determine most appropriate methods of analysis and apply as needed; i.e., watersheds, basins, areas of coal deposits, etc., as opposed to arbitrarily bounded States, counties, EPA jurisdictions, reservations, etc. This suggests, where possible, the selection of problems to fit known methods of solution as opposed to

developing ultra-complex methods for solution of arbitrarily defined problems.

50. Develop methods, specifically applicable to the region, for linking various approaches already developed for separate systems. These include the ecosystem, mineral processing systems, energy systems, transportation systems, economic systems, government, and policy systems.

Discussion: At the risk of seeming repetitive, the technological complexity of our society does not permit an approach to understanding and decision making which deals with isolated problems. The per capita energy use of roughly 100 times that needed to sustain life is clear evidence that a machine exists which is consuming 99 percent of our energy and therefore presumably accounts for 99 percent of whatever man-caused activity is going on.

This machine processes energy which, in turn, is used to process or act upon materials, information, people, and life processes. A very large fraction of this machine, in terms of sheer weight of hardware, is fed by our natural resources of minerals, water, and energy. It is possible by throwing a switch or turning a valve to stop an automobile or to shut off the power to New York City. One characteristic of manmade machines is expressed in the following quotation heard about ten years ago at a meeting of chemical process engineers:

"Thou shalt remember that refinery processes do not change by meditations, however profound, but by turning the valve."

The speaker was referring to discussion of "computerizing" refineries. The speaker was stating quite clearly that what goes on in the computer does not affect, directly, the process. Much of the current activity in modeling of economic, social, and ecosystems (using this latter term in the restricted sense of the bounded, life sustaining, biological system) is being subjected to the same criticism for the same reasons. However, there is a lesson to be learned from the experience with computers in the chemical process industry. In order to even begin to use the computers the chemical engineers were forced to define precisely what was going on in the process--to make a quantitative model. The experiences of several companies was that by the time they had defined the process well enough to use the computer they had so improved their understanding of the process that they could substantially improve efficiency of operation without using the computer.

Table 1 and Table 5 of this report are examples of "models"--which loosely define relationships but are not at all quantitative. It should be evident after a little meditation on the items listed in these tables and after review of the 46 projects listed in previous sections that an improved quantitative understanding of interaction among the many

items identified is essential to the guidance of mineral/energy/environmental decision making. We have a degree of understanding of the components of the system from which we extract our minerals (the ecosystem), the system which processes these minerals (to coin a word--the technosystem), the system which uses the minerals (the social system), and the systems which regulate transactions (economic and governmental systems). There are many modeling techniques under development, in existence, and in use which are potentially or proven useful.³⁷ Unfortunately, in recent years, there seems to have been more effort on developing models than on using models. The corollary to the quote above might be that "models do not provide useful results by manipulation, however adroit, but by plugging in numbers."

The pressing research need is to apply the techniques we have developed, using computers as an aid to understanding, but with emphasis on the judgments of and interactions among knowledgeable people in the provision of quantitative information for insertion into the model and in the evaluation on the validity of results obtained from the modeling operation. It is equally pressing that we stop the myopic, one-alley, finger-pointing approach which has coined phrases such as: Technology brought on this mess; it's merely a matter of economics; those bureaucrats in Washington---; if the public weren't so apathetic---; we should forget the rest of the world and take care of ourselves; and, as wrong as the first statement: technology will bail us out. Bailing the boat will not keep the lake from running dry. It is the lake--our resources--not the boat that is critically in need of management.

The oil embargo is an example of "valve-turning" on a grand and effective scale, which also indicates clearly that the "machine" will respond to any one of a number of valve turners without judgment of the consequences to the jobs and lifestyles of people enmeshed in the machine. The embargo and our national reaction to the crisis which has resulted also illustrates emphatically that, although a valve was literally turned, neither the solution nor the problem are technological.* All of the dimensions in the Framework of Table 5 are involved. A comprehensive analytical framework, a model, if in existence might, at least, point the direction to areas of policy, mining operations, institutional arrangements, etc., which are most critical to success in solution of the problem.

*The New York blackout, incidentally, was basically a technological problem.

5. PRIORITY OF NEEDS

Anyone who reads this section of this report without having read the foregoing text does so at the risk of drawing unfounded conclusions. This does *not* suggest that the conclusions relative to priorities presented herein are "unfounded" in the opinion of the task force. They *are not* the consensus of the task force. Any conclusion made by the reader as the rightness or wrongness of the priorities presented here should be made with as complete knowledge as possible of the context in which they were established and the assumptions upon which they are based which are summarized in preceding sections. The most important point to be made is that priorities are conclusions of individuals made in the context of that individual's perception, experience, and frame of reference. Among those who read this report will be some, hopefully, whose assessment of priorities will be more valid in the total regional context than those presented here.

The members of the task force who prepared the final draft all contributed to the priority ranking presented here on a basis of a ranking system consisting of four levels. The ranking was done independently. It is significant to note that in the results:

1. Only one project received less than three levels of ranking in the independent evaluations.
2. Every project was given at least one ranking at level No. 1 by one of the evaluators.
3. Every project was given at least one ranking at level 3 or 4 by one of the evaluators.
4. No projects were ranked by the entire group or by less than 5 members of the group. (Instructions were that if the individual did not feel sufficiently well informed on a project he should not rank that project.)

These results further emphasize that these priority rankings should not be accepted or rejected without very careful consideration on the part of the reader.

With these enjoiners as background the following discussion will set the stage for the tabulation of priority rankings.

After a relatively low-key quibbling about words, the task force agreed to adopt, in principle, the following system of priority ranking developed by the task force on Water Resources and Uses. (There was some concern about "probability of payoff" being in A and improvement of "management efficiency" in C. There was resounding agreement with the idea of "irreversibility" and "weakest link" being rated high).

A-CRITICAL

This research:

- will provide for the solution of important problems that cannot now be solved, or
- will indicate how to prevent damages (particularly those relating to irreversible effects) from occurring, or
- is expected to have a high *probability of payoff*, or
- will consider the weakest links in complex systems where there are interrelated parts.

B-URGENT

The solution of these problems:

- will enhance the environment but not deal totally with *irreversible* questions, or
- will have economic impact of high social value.

C-IMPORTANT

This research:

- will improve management efficiency, or
- will have potential high payoff, but will have lower probability of success than A or B, or
- will depend on findings of other studies before it can be proved.

D-SIGNIFICANT

Problems which:

- should have studies to explore feasibility as a minimum, or
- have a relatively narrow range of applicability.

The task force also discussed, and realized the impracticality of using (in the time available), a three-dimensional concept of priorities shown in the diagram below. A little study of this diagram and roundtable discussion with associates is much more valuable than any long narration that might be presented here. Some examples of *error* will serve to illustrate the problem.

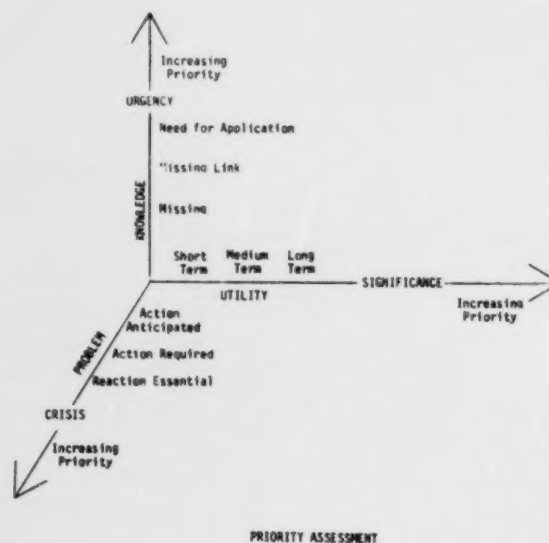
Error Type I: Spend a lot of money on research to obtain missing information when it is clearly apparent that the results will have only marginal implications (very few people remember results which are illustrative of this type of error).

Error Type II: Spend a lot of money on research to obtain missing information for an urgently needed application when it is clearly apparent that the absence

of other information, the missing link, makes the probability of success extremely low (lowest is "next to impossible," next lowest is "purely by chance").

Error Type III: Divert effort from projects clearly of significant long term utility dealing with anticipated needs for application and action in order to react to crisis with remedies of short term utility (also known as the band-aid approach).

Error Type IV: Take action in anticipation of needs for application on the basis of extrapolation of past experiences without projecting trends and long term utility (the Maginot Line approach).



Another aspect of priority ranking relates to the measure of effort applied. High priority can mean worth the highest funding level, the most important thing for a small group of experts (including single) to be doing, the thing that should be done first, the effort that should be sustained most consistently, etc. In this sense of priority the task force feels that all of the items listed in section 4 merit inclusion in a long-range program of research at an appropriate level of activity and would also argue that top priority items on the list should not, arbitrarily, mean top funding.

The task force is fully aware that research is going on in most of the areas identified in section 4. Reference has been made to some of this research in this report. Other research is knowingly omitted. It is also quite likely that research is going on which was not known to the task force. The priorities suggested here, therefore, should be at least reviewed in the light of a more complete assessment of existing research activity.

The task force also has opinions as to who should support the research (the individual industry, the industry associations, state, regional, federal organizations) but did not feel that it was pertinent to enter into this realm of discussion.

With all of these qualifications, admonitions, and awareness of the limitations in judgment implied, the following tabulation of priorities for the research needs presented in section 4 is presented.

6. RESEARCH STRATEGY

Much of the discussion in the foregoing sections of this report has dealt with the strategy of research as it is related to subject matter. Perhaps the most important comment to be made is to reiterate the need for a *campaign* strategy which integrates the impact of individual projects on a overall objective. In addition this approach should avoid the counterpart of this integration--the missing link problem which is not detected without integration. (For want of a nail the shoe was lost, etc.)

Other elements of research strategy are essentially subdivisions of this overriding concern. The following summarizes comments made by various members of the task force.

Over the past decade or two, there has been an explosion in technology, research, and development. And it seems to be generally recognized that we could gain untold additional benefits from putting to use what we already

PRIORITY RANKING FOR RESEARCH NEEDS OUTLINED IN SECTION 4

(This tabulation should not be used for guidance without reading Section 5)

(Order of listing within categories has no priority significance)

A. CRITICAL	B. URGENT	C. IMPORTANT	D. SIGNIFICANT
3* Ore recovery*	1 Exploration methods	25 Physiological & behavioral response of animal life	4 Metallurgical processes
8 Integrated approach to planning mining operations	2 In-situ leaching	28 Inventory of existing information	6 Reduction of hazards to wildlife & domestic animals
12 Reclamation of disturbed, harsh, arid areas	5 Secondary mineral recovery	29 Program of uniform & comparable sampling, collection & analytical methodologies	7 Joint industry/university effort on specific energy related processes
20 Use of water by mining operations	9 Control of acid water from underground operations	30 Interactive relationships among regional characteristics	15 Small-scale terrain water management
26 Projection of tradeoffs among competitive uses for water & land	10 Control of tailing ponds & piles	33 Technology assessment	18 Methods of compensation for owners of private property
34 Positive incentive approaches	11 Overburden removal & practice	39 International arrangements	31 Methods for paying social & environmental costs
35 Excessive regulatory requirements by multiple jurisdictions	13 Soil characteristics of disturbed surface and spoils	41 Gov't institutions for supervision of planning for integrated mining operation	32 Economic assessment
45 Regional authorities crossing state lines	14 Vegetation suitable for reclamation	42 Institutional arrangements for approval of power plant siting	36 State-level land mgmt.
47 Regional information retrieval system	16 Field trials of reclamation management practice	43 Regional & subregional objectives	37 Interstate legislative interaction
49 Identify subregional areas for system analysis	17 Impact of public land withdrawals	44 Categorization of policy making entities	38 Legal & jurisdictional questions of ownership & control
	19 Planning for social needs	48 Apply modeling techniques to synthesis	40 Energy agri-industrial centers
	22 Effects of geothermal energy production		50 Regionally applicable linkages of modeling approaches
	24 Effects on natural vegetation		

*Project No. & Abbreviated Subject

know. This does not argue against research but rather for a somewhat different approach toward its use and being more selective in the adoption of new research programs, while assuring that programs are structured toward some useful end.

Our charge is to identify research activities that will assist *decision makers* in arriving at appropriate courses of action, etc. Decision makers are usually practical people who are motivated by economic, political, and sometimes social, legal, and emotional considerations. If research recommended in this report is carried out and results are not demonstrated to relate to these concerns in our society they will be of limited value to the decision maker and frustrating for the researcher.

Many activities should be conducted on a regional, basin, or watershed basis instead of by individual project. These activities include: baseline surveys of the bioenvironmental community to establish present conditions and to provide reliable data to determine the reclamation potential; monitoring the biological and abiotic environment to determine cumulative impacts of industrial developments; and regional planning to give broad consideration to alternatives and to allow orderly development and retirement of industrial (especially energy related) developments with their attendant requirements (such as water).

Disturbed land reclamation research in the past has had very little continuity. Reliable funding which will enable planning and work to continue over a long, perhaps indefinite, period is one of our most urgent needs. The U.S. Forest Service has probably funded more of this research than anyone else, but even they have had to beg the legislature for funds on a year-to-year basis.

Long-term management programs need to be established. There has been a tendency, indeed it is a common practice in the East, to release reclaimed areas and allow over-grazing and other poor management practices to destroy the reclamation effort.

Engineering studies to supplement scientific research should be encouraged. Such studies have been largely neglected because they are expensive. Equipment and methods to handle top soil, overburden, and spoils; spoil and hydrology designs; and cultivation and irrigation equipment for spoils have been developed by instinct and expediency.

Model projects which include everything from initial design through completed results are needed to demonstrate to both industry and the public that the problems are not insurmountable and, at the same time, allow funds to be focused on controlled-research sites. These should include

before-disturbance assessments of overburden materials which would allow some intelligent planning with regard to spoil slope and design, surface water management, and soil potential and fertilizer requirements for revegetation.

The general need for emphasis on the interactive nature of the problems emphasizes the need for interactive, interdisciplinary research. The prerequisite to this occurring is the development of a research community, not only a collection of appropriate skills and interest but a genuine community with concern for the regional problems and willingness to communicate in arriving at realistic objectives and to cooperate in reaching viable solutions.

7. NON-RESEARCH RECOMMENDATIONS

Several of the research needs identified in section 4 are "borderline" in terms of whether or not they should be called research, development, planning, management, or administration. This does not belittle their importance but suggests that the task force felt some study or review was needed before action was justified on the basis of task force recommendations. With these reservations the task force would recommend that action be taken by appropriate agencies and organizations without a great deal of research in the formalized sense, on the following items described as research needs:

8. Integrated approach to planning mining operations.
28. Inventory of existing information.
32. Establishment of a regional technology assessment capability.
37. Establishment of a forum for legislative interaction.
40. Development of agri-industrial centers.
42. Streamline institutional arrangements for approval of power plant siting.

Other recommendations are the following:

Develop college level education programs relating to plant and animal culture or reclamation of harsh, arid disturbed lands.

Coordinate any mineral and energy related research activities which may result from this project with activities resulting from other task force recommendations, particularly those related to water resources and use, institutional arrangements and competing uses, and with any similar activities already in progress or completed.

Formulate public policies at the interstate, regional levels which provide mandates or incentives for:

- a. Collaborative research of an on-going nature among academic institutions, including creating possible new special R & D centers.
- b. Involvement of federal R & D laboratories in regional research and problem-solving (e.g., Los Alamos Scientific Laboratory, National Center for Atmospheric Research, National Reactor Testing Station, etc.). Note: this would probably entail some redirection in federal policies also.
- c. Development of new institutional arrangements for conducting advanced technology assessment and technological forecasting studies, long-range planning and policy studies, providing scientific advice to government agencies, as well as performing actual applied research.

Develop improved science/industry/government interaction "across-the-board." Many of our lawmakers find it difficult to obtain timely scientific advice and information during their deliberations. Likewise, some of our governors and executive branch officials are often pressed to make decisions on the basis of fragmentary, incomplete information. Clearly, some better communications and "feedback" system is needed between the Region's scientific and industrial community and government.

Last but not least, avoid creation of any monolithic, regional organization which might attempt to carry out a comprehensive research program in the Rocky Mountain area. We should recognize the desirability of the pluralistic approach, while simultaneously discouraging a proliferation of uncoordinated, duplicative, and consequently ineffectual research studies.

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APPENDIX

ENERGY MINERALS



COAL

2 DOMESTIC RESOURCES - 50%
YIELD - $\frac{\text{COAL}}{\text{COAL} + \text{OVERBURDEN}}$

ENERGY MINERALS



OIL AND GAS

2 DOMESTIC RESOURCES - 25%
YIELD - WELL PRODUCTION

ENERGY MINERALS



OIL SHALE

2 DOMESTIC RESOURCES - 100%
YIELD - 10 - 25 GALLONS/TON

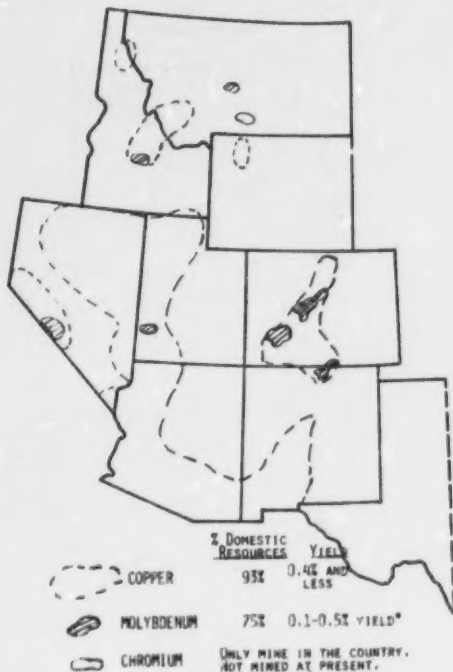
ENERGY MINERALS



URANIUM

2 DOMESTIC RESOURCES - 100%
YIELD - 0.23

STRUCTURAL METALS



*ALSO MINED WITH COPPER 0.015-0.1%

FERTILIZER MINERALS



MISCELLANEOUS MINERALS



*ALSO FOUND WITH OIL SHALE 13-76%
**0.3% WITH NATURAL GAS

*ALSO MINED WITH COPPER

COMPOSITE OF SELECTED MINERALS





E. RECREATION AND TOURISM

Task Force Leader: Perry Brown

114<



RMER-Quest

Task Group Report

RECREATION AND TOURISM

June 24, 1974

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ABSTRACT

In this report major research issues dealing with leisure, recreation, and tourism in the Rocky Mountain Region are identified and examined. The focus of the report is on issues around which research programs can be built rather than on specific problems. It is the recommendation of the Recreation and Tourism task force that programs be built around the following issues:

1. Impacts (physical, biological, social, and economic) of the provision of recreation opportunities and use;
2. Nature and characteristics of tourism and recreationally oriented communities within the Rocky Mountain Region;
3. Resource allocation decisions regarding the providing of recreation opportunities;
4. Motivation to engage in leisure time experiences and resulting satisfactions and benefits;
5. Relationship among administrators and researchers in identifying research problems and implementing research findings;
6. Management systems applicable to insuring production and maintenance of recreation opportunities;
7. Definition of natural resources by diverse publics and resulting resource values.

These seven issues are discussed in the report for their regional relevance and some of their dimensions. General problem and project areas within these issues are identified. Each of the problem or project areas is briefly discussed, giving an indication of expected research outputs.

RECREATION AND TOURISM

INTRODUCTION

Abundant opportunities for outdoor recreation are an asset of the Rocky Mountain Region. Providing these opportunities is an important function of all levels of government and is also an activity of private enterprise. The Region has vast acreages of federal and state land devoted to the provision of recreation opportunities, while many of the Region's communities contain numerous facilities in the private sector which enhance recreational opportunities provided on public lands.

The provision of opportunities for outdoor recreation and the resulting recreational activity presents possibilities for economic, social, and ecological impacts. These are both positive and negative and it is important to find ways to enhance the positive impacts while mitigating those impacts that are perceived as negative. As in the past, research can play a role in aiding the functions of outdoor recreation planning and management to deal with these impacts.

In this report, major issues dealing with leisure, recreation, and tourism in the Rocky Mountain Region are identified and examined. Most of these can be researched. In some cases, administrative arrangements could be modified to effect problem solution and no research would be needed.

The focus of the report is on issues around which research programs can be built rather than on individual research projects. This approach has two advantages. It permits the identification of broad issues which are not specifically tied to one time period and it permits the inclusion of individual projects into research programs at a later date. Undoubtedly, there are relevant projects which were overlooked during this

analysis. Thus, this approach leads to identification of problem areas relevant to the Rocky Mountain Region and is adaptive to a changing environment. The relevancy of individual projects may change between now and fifty years hence, while the broad issues with new twists will still be relevant.

On the following pages the procedures used to identify leisure, recreation, and tourism issues and possible projects within them are explained. Then, each issue is discussed and some possible projects within each are identified. The order for discussion of issues reflects a priority ranking based upon an analysis of regional relevance plus an overall priority evaluation.

PROCEDURE

Two groups of leisure, recreation, and tourism experts were assembled to make the analysis. A task group was organized to provide the basic idea input, while a broader group was combined with the task group to act as critics, add additional ideas, and aid in prioritization of issues.

The task group was composed of individuals representing areas of expertise, geographic areas, and knowledge of recreation research. Areas of expertise represented included disciplines such as economics, ecology, political science, social psychology, geography, public administration and management systems, as well as specific areas such as tourism, national parks, wild rivers, wilderness, and esthetics. Rocky Mountain States represented on the task group were Arizona, Colorado, Utah, and Montana, plus the province of Alberta.

The group of critics and advisors was made up of people who had specific areas of expertise (some different from the task group), knowledge of recreation planning and manage-

ment issues, and represented various geographic areas. The States represented in this group were Colorado, Nevada, New Mexico, and Utah.

This report was prepared from the input of these two groups.

A meeting of the task group was held to settle on the task and devise a strategy to accomplish it. After the meeting, task group members developed working papers based upon their subject expertise (behavior, management systems, etc.) for a second meeting which involved many of the critics. The procedure for the working papers was: (1) list the regional issues or problems about leisure; (2) select the five most important issues giving a rationale for selection; and (3) examine the five issues with regard to scope, state-of-the-art, needed research, possible management solutions, problems in implementing research or management solutions, and linkages with other task forces. These papers were the basic ingredient for a second meeting and were given to both the task group and the expanded group of critics.

A second meeting of the task group, to which critics and reviewers were invited, was held to examine contents of the papers, identify any other important issues, and develop a strategy for melding the analysis into a report document. While the issues were discussed and a listing of important broad issues came out of the meeting, greatest success achieved at this meeting was in formulating a strategy for report preparation.

The strategy developed was designed to provide evaluation of each issue and problem for its regional relevance and solution characteristics. For this purpose a matrix (table) was developed. Rows in the matrix consisted of the issues and specific problems or projects within these issues. The columns were divided into three classes: (1) important regional

determinants; (2) solution criteria; and (3) solution expertise.

To identify regional relevance, three determinants of the Region's recreational character were used as criteria: water, energy, and federal land ownership. The demand for and distribution of these factors have specific regional meanings. Water has been an important historical factor in the Region's development and will continue to play a pivotal role in the future. Energy has two regional meanings which are important. First, the Region is vast and it requires large amounts of energy to travel to and throughout it. Second, the Region is the reservoir of large quantities of gas, oil, and coal for which there will be increasing demand in the short run (next 30-50 years). As these energy sources are tapped for export and internal use, the Region's character and leisure time demands are surely going to change. Federal land ownership is important because a large amount (approximately 49%) of the Region's land is under federal control and many of the Region's recreation opportunities are provided on these vast federal acreages.

The columns for solution criteria dealt with state-of-the-art, researchability, administrative (management, planning) need, administrative arrangement problems (not needing research), solution time estimates, and an overall priority ranking. A high-low, long-short type of evaluation was made for each criterion.

The final set of columns dealt with the solution expertise which might be applied to the problem. The categories were: behavior (including economic demand); regional economics; political science (both public administration and political analysis); natural and physical science; geography; and administrative (actual administration). These areas of

Issue	Overall Priority	Regional Determinants	Combined Rank
Impacts	3	2	1
Tourist Communities	6	1	2
Resource Allocation	5	2	3
Motivation Behavior	2	5	4
Research/Administrator Relationship	1	7	5
Management Systems	4	6	6
Definition of Natural Resources	7	4	7

Table 1 Ranks for the issues utilizing the regional determinants and overall priority criteria plus a combined criteria rank.

expertise provided a look at the interdisciplinary nature of the problems and possible approaches to solutions.

This evaluation matrix was distributed to task group members and critics. Their responses were used to prioritize the major issues and identify factors that are important for both the issues and their specific problems and projects. In prioritizing the issues, both the regional determinants and the overall priority ratings from the matrix were used. These two criteria produced different rank orders, as is shown in Table 1, and thus they need to be combined to produce a final rank order. In this combining process, a bias toward regional relevance was employed to eliminate tie scores. This combined rank order is also shown in Table 1.

From the evaluation made using the matrix, the original papers drafted by the task group, discussions with the task group and its critics, and communications with task group members and others, the remainder of this report was prepared. The issues below are those deemed most important, for the Region, by the task group. Other issues were eliminated during the several stages of evaluation.

ISSUES

The important, regionally relevant issues are listed below in order of their current and near future importance. Their rank order may change over time as the problems which can be identified within each are solved or as the environment changes.

1. Impacts (physical, biological, social, and economic) of providing recreation opportunities and recreation use;
2. Nature and characteristics of tourism and recreationally oriented communities within the Rocky Mountain Region;
3. Resource allocation decisions regarding the providing of recreation opportunities;
4. Motivation to engage in leisure-time experiences and resulting satisfactions and benefits;
5. Relationship among administrators and researchers in identifying research problems and implementing research findings;
6. Management systems applicable to insuring production and maintenance of recreation opportunities;
7. Definition of natural resources by diverse publics and resulting resource values.

It must be emphasized that these are all extremely important issue areas around which research programs might be built. The rank attached to each issue basically reflects its regional specificity. All these issues are, however, regionally relevant and deserve attention.

IMPACTS OF THE PROVISION AND USE OF RECREATIONAL OPPORTUNITIES

SCOPE AND REGIONAL RELEVANCE

The scope of this "impacts" issue is very broad. It includes impacts of providing and using recreational opportunities on the physical, biological, social, and economic aspects of the Region's environments. One might wish to consider research programs to determine recreational impacts on each of these systems. Our central point, however, is that programs need to be designed to focus on impacts.

This broad issue is clearly related to all three regional determinants: water, energy, and federal land. The issue covers such things as the impacts of development, facilities, equipment, and recreationists on plants and animals, relationships between the provision of recreation opportunities (like campgrounds, reservoirs for boating and fishing, and wilderness oriented recreation opportunities) and local economic and social structures, and conflicts between the production of recreation opportunities and other commodities, including wilderness areas.

SOLUTION CRITERIA

Overall, the state-of-the-art with regard to assessing impacts from the provision and use of recreational opportunities encompasses a moderate amount of published work. Considerable data are available on physical and biological impacts, with the exception of impacts on wildlife. Less is known about social and economic impacts, but some work has been done there also--particularly with regard to tourism. Research on the means to mitigate many impacts has not been conducted.

Researchability (or whether or not it can be researched) of this topic is very high. Almost any problem identified within this issue is highly researchable though some problems (particularly economic and social) might require new or modified methodologies. Administrative need is also high for answers to problems within this issue. Solution time to solve most of the problems is moderately long (2-4 years) to long (greater than 4 years), though some answers (such as those for some impacts on wildlife and economic impacts) could be generated quite quickly.

This issue is not one which can be dealt with through administrative re-arrangement, except to the extent which administrators might or might not accept various ways to mitigate negative impacts or foster positive impacts.

SOLUTION EXPERTISE

Simply, all the expertise areas identified in the matrix are applicable to this issue. Biologists, economists, geographers, physical scientists, sociologists, and many others can

contribute substantively to individual projects under this broad issue.

PROBLEMS WITHIN ISSUE

Many projects are possible within this "impacts" issue. There are several products which could be the outcome of completing each project, but one that is common to all is basic information for preparation of environmental assessments and impact statements. Some of the possible projects, with an indication of some of their possible products, are listed below.

- A. To determine what impacts accrue to communities when recreation opportunities (private and public, highly developed and undeveloped) are provided nearby.

A first product from this research would be identification of kinds of impacts which are made on communities. Then, investigation might be made of the magnitude of impact; thus producing guidelines for estimating impacts of new recreational developments.

- B. To determine what impacts on national welfare accrue from provision of recreation opportunities in the Rocky Mountain Region. Such items as the effects on income distribution, jobs, and population location and migration might be considered.

Among the outputs of this research would be information fitting the "national economic development" account of the Water Resource Council's procedures for project evaluation. Additionally, one would obtain information relative to developing population migration models and other regional planning tools.

- C. To determine the effects of the provision of recreation opportunities on regional and local welfare. Effects on income distribution, jobs, diversity of economic base, and population location might be considered.

Some of the information generated in this study would be pertinent to the Water Resource Council's regional account.

- D. To determine how providing recreation opportunities affects the production of other commodities. Items to investigate would include effects of recreation on the production of clean water, forage, other recreation opportunities, wilderness, and many other land based products.

This research would lead directly to assessing trade-offs between the production of different commodities. The information produced ties in directly to requirements for impact assessment under the National

Environmental Policy Act and the project evaluation requirements of the Water Resource Council.

- E. To determine the extent to which recreation impacts archeological and historical sites and materials.

Essentially this research would focus on conflicts between recreation and preservation of historical and archeological artifacts. The output would be methods and guidelines for assessing impacts on these artifacts.

- F. To determine where impacts of recreation will occur due to water shortages, fuel shortages, population location, and production of other commodities. This means examining the determinants of the location of recreational opportunity and the impacts which result from changes in these determinants.

The products might be increased understanding of the influence of probable locational determinants and greater predictability of the environmental conditions resulting from spatial arrangements produced by these determinants.

- G. To identify the conceptual and technical problems in inventory of resources for recreation. This implies a re-examination of past and current inventory systems.

A product of this research would be knowledge for assessing the impact of any particular inventory system, and the decisions utilizing it, on the social, economic and natural environments. Basic information for designing an effective and efficient inventory system would be generated.

- H. To determine the impacts of the provision of recreation opportunities on the preferences of recreationists. To what extent are preferences built on experience with the available supply?

Information generated from a study such as this is basic to understanding demand for recreational services and the relationship among demand and consumption. Such information is important for planning the recreational opportunities to be supplied.

- I. To identify the societal benefits from peoples' participation in recreation. Some things which might be considered are the impacts of recreation on work production, community spirit and cooperation, and other societal goals.

An output of research on this topic would be an identification of the effect of providing recreational opportunities on the goals of a society. Such information could contribute substantially to decisions about who should pay the cost of recreational developments.

- J. To determine the impacts of the provision of recreational opportunities on wildlife populations. This problem is identified specifically because the literature reveals little published work on this topic.

From this research could come information to assess the impact of recreation developments and management tools on wildlife populations. Such information would clearly fit the requirements of the National Environmental Policy Act and the Environmental Quality objective of the Water Resource Council project evaluation procedures.

For each of these problems there are obviously many sub-problems which might make up individual studies. However, it is beyond the scope of this report to attempt to list all these possible projects. The problems listed illustrate the diversity of topics within the "impacts" issue and identify some of the problems needing solution.

NATURE AND CHARACTERISTICS OF TOURISM AND RECREATIONALLY ORIENTED COMMUNITIES WITHIN THE ROCKY MOUNTAIN REGION

SCOPE AND REGIONAL RELEVANCE

The Rocky Mountain Region has two characteristic kinds of recreationally oriented communities. First, there are the resort communities which have been built or rebuilt (usually from abandoned mining towns) on a recreation oriented economic base and usually emphasizing winter sports and esthetic resources. Such places as Vail, Colorado; Sun Valley, Idaho; and the Big Sky Complex in Montana come to mind. Second homes and condominiums are often associated with these communities. The second category includes those existing communities which have developed a strong tourism orientation and economic base. These communities are often in close proximity to national parks. Such places as Kalispell, Montana; Jackson, Wyoming; Moab, Utah; Flagstaff, Arizona; and Reno, Nevada are examples.

With regard to both of these kinds of communities there are several issues which are important. Generally one can look at these places as rapidly expanding communities, in restricted environmental settings, that are often built on a narrow economic base of tourist services, recreation activities, and real estate transactions. Major problems in them are related to rapid growth, environmental change and often degradation, and dependency on one industry.

There can be little question that this issue is one of prime regional concern. These communities are part of the character of the Region and make up much of its extra-regional image. No other region has the same kind of tourism communities as has the Rocky Mountain Region. The relationship of these communities to water is not as strong as to the other regional determinants except that their

location is historically dependent upon water resources and the valleys along water courses. Linkages to energy are quite clear. Many of these communities are in sparsely populated areas and thus depend upon the state and national transportation networks to bring in tourists and other recreationists. In some cases communities are located in areas which are likely to receive impact from development of energy resources in the Region. Also, the issue of energy use in these communities is important. Many of them are in high mountain areas where, because of weather patterns, energy consumption for heating and lighting is relatively high. The relationship of these areas to public lands is also quite clear. Many of these communities are dependent upon access to federal lands for skiing, hiking, jeeping, and other recreational activities. Much of the esthetic setting of these areas is dependent upon federal land and often these communities are restricted spatially by surrounding federal lands.

SOLUTION CRITERIA

The state-of-the-art, as evidenced by the amount and quality of literature, with regard to this "communities" issue is moderate to low in development. Analyses of parts of the total picture have been undertaken at many areas. For instance, one finds economic analysis of Jackson, Wyoming, environmental analysis of Aspen, Colorado, and analysis of tourism and tourist behavior in Moab, Utah.

The issue is highly researchable and there is high administrative need to find answers to many problem oriented questions. Many regional planning and development techniques can be utilized to study this issue. What is currently needed is a case study application of these tools over a community system to provide the comprehensive information needed for decision making. There may be need to develop some new tools to close methodological gaps and there is definitely a need to develop comprehensible information delivery systems so that decision makers and various publics can examine the consequences of actions without developing highly technical skills. Administrators in many counties and communities, as well as many potential developers, are asking for a more solid information base.

The solution time for this general issue, in terms of a case study and methodology development, is moderate (2-4 years). To examine a large number of such communities would take considerably more time. Also, re-evaluation of some communities at a later date would likely be advantageous to monitor changes over time. This would also provide an opportunity to test the validity of decision making tools and techniques.

The possibility of solving some of the problems inherent in this issue through administrative re-arrangement appear high. This is particularly true for problems of coordination between various public agencies.

SOLUTION EXPERTISE

Because of the broad base of this issue, all of the areas of expertise examined by the task group have a significant role in the problem solution. Political scientists, biologists, economists, geographers, management specialists and many others can logically contribute to understanding the issue and finding solutions to problems identified within it.

PROBLEMS WITHIN ISSUE

Some of the problems and possible projects within the "communities" issue are listed below.

- A. To identify the social, political, and economic structures of tourism and recreationally based communities.

Research on this topic is necessary to describe the current state and functioning of these communities. Being able to describe these systems is necessary for assessing impacts on them from such events as fuel shortages, high inflation rates, or competing developments.

- B. To determine acceptable (to relevant publics) balances between natural amenities and social and economic forces in these tourism and recreationally based communities.

An output of research on this topic would be guidelines for determining how much development is possible without diminishing the quality of the resource base upon which development success has been generated. Another output would be the techniques developed to assess the acceptable balance as perceived by relevant publics.

- C. To determine what pressures tourism and recreationally based communities place on adjacent public lands and to predict what pressures might emerge in the future.

Information useful for planning the recreational facilities offered by both public and private suppliers would be gained through this effort. The relationships among communities and public lands would be understood and the expectations of community residents and visitors dealing with public land would be identified. This information could be used in both planning and management decisions.

- D. To determine how public land management agencies can serve the tourism and recreationally oriented communities and yet maintain their legal identity (federal, state, local). This project is derived directly from results of project C.

Results of this study would be identification of the roles public land management agencies can plan in enhanc-

ing community viability. Policy decisions regarding agency roles in provision of recreational opportunities and community enhancement are likely outcomes.

- E. To predict what changes are likely to occur in tourism and recreationally based communities with a changing energy supply situation.

A likely output of this kind of study would be scenarios giving alternative futures for these communities. From these, strategies might be developed on how to reach a desired future or mitigate adverse effects of fuel supply changes.

- F. To predict which communities will survive, which can be made to survive, and which are likely to be lost with a changing energy supply.

The output of this descriptive research is prediction of the effects of a changing energy supply on tourism and recreationally based communities. A primary use of this information might be by state governments in making investment decisions. Particularly important are investment decisions to mitigate adverse economic effects on communities arising from a challenging economic environment.

- G. To identify the kinds of information (social, economic, natural environment, etc.) that are needed by local decision makers to plan for the adjustment, maintenance, and growth of tourism and recreationally oriented communities. Of particular concern are those towns located in environmentally restrictive areas.

What emerges from this type of research is an understanding of the kind, amount, and sophistication of information which can be utilized by local decision makers in planning. A question to be answered is, how detailed can information be and still be of use to local decision makers?

- H. To determine what delivery systems, for the kinds of information identified in G, are feasible and useful for local decision makers.

The output of this effort would be a set of techniques and guidelines for delivery of information to local decision makers.

- I. To determine what growth of tourism facilities, second home and other residential growth, and industrial growth mean to tourism and recreationally based communities in benefit-cost terms.

A likely procedure for this research would be to assess the impact of several alternative futures on the current state system. The resulting output would be an under-

standing of what changes in the system are likely to accrue from various growth alternatives.

- J. To identify the arguments (in terms of psychological needs, energy usage, community stabilization, income distribution, etc.) for and against the maintenance of tourism and recreationally based communities given a changing energy supply.

Essentially the product from this research would be an understanding of pros and cons of maintaining and possibly investing in these communities, from the viewpoint of public welfare. The information generated might readily fit into state and federal level investment decisions.

These are some of the problems within the "communities" issue which need solution. The list emphasizes two points: (a) the need for a systems look at these communities and (b) the situation of a changing energy supply. A systems analysis of the communities permits comprehension and the assessment of the effects of system modifications. The energy focus recognizes the spatial distribution of these communities and their current dependence upon state and federal transportation facilities designed for automobiles.

RESOURCE ALLOCATION DECISIONS REGARDING THE PROVIDING OF RECREATIONAL OPPORTUNITIES

SCOPE AND REGIONAL RELEVANCE

Natural resources play a significant role in the character of the Rocky Mountain Region and decisions about their allocation are of particular concern. Water allocation has been extremely influential in the spatial and temporal development of the area while energy resources and federal lands have been increasing in importance.

There is concern over how decisions are made and what events (both formal and informal) influence these processes. What are and might be the roles of publics in these decisions and what kinds and levels of information are necessary in these processes? These are some of the questions which can be asked for all resource allocation as well as the allocation of resources to recreation.

Some examples of the need to solve problems within this issue deal with water developments such as dams and water diversions, dedication of national parks and wilderness areas, and the extraction of coal and oil shale from vast land areas. At a more recreationally specific scale there are concerns with decisions to develop recreation areas and decisions to provide opportunities to engage in certain recreation activities.

SOLUTION CRITERIA

The state-of-the-art in terms of accepted allocation procedures, is moderate to low in development. While many of the relevant issues have been conceptualized, solutions to problems have been lacking. This is partly due to the intra-disciplinary research undertaken in this arena and the lack of incorporation of research results into decision making.

Both the possibility to research the issue and administrative need for research results are quite high. However, there is some question about how much of the research can lead to solving problems since some political events are not clearly systematic. It might be argued that until we identify the present resource allocation decision processes which are operative, we cannot determine how researchable other questions might be. With regard to administrative need there is little question that decision makers need better resource allocation tools--ones that are more comprehensible than those generally being developed today.

It appears that considerable work needs to be done on this issue, probably in distinct phases. Therefore, while some specific problems may be solved in a short time, most of the issue's problems will not be solved for some time to come (greater than 4 years).

This "resource allocation" issue has some aspects which can be dealt with through administrative re-arrangement and do not necessarily need research. Definition of the roles of different recreation suppliers and arrangement of budgeting structures to recognize these roles is an example. In addition, internal budgeting re-arrangements for some agencies would probably lead to different forms of allocation.

SOLUTION EXPERTISE

All of the areas of expertise examined have relevance for this "resource allocation" issue. Political science, behavioral, and administrative expertise are probably the most clearly linked, however.

PROBLEMS WITHIN ISSUE

Thirteen problems are listed below which fit within this "resource allocation" issue.

- A. To identify the formal resource allocation decision processes and how they are structured.

This research is necessary to understand how decision processes are structured and operate. It would provide a base for further investigations into decision-making processes and how they might be altered.

- B To determine how formal resource allocation decision processes are influenced by informal events and pressures. This research is a natural follow-up to A.

The output of an effort such as this would be an understanding of how decisions are actually made. The study would produce information necessary for understanding how resource allocation decision processes might be altered.

- C To identify the kinds and levels of information (economic, social, biological, psychological, etc.) that are useful in resource allocation decision processes.

Research such as this would produce guidelines for collection of data necessary for decision-making processes to operate. Additionally, significant unfulfilled data needs might be identified and work initiated to fill the voids.

- D To determine how necessary information for resource allocation decisions can be delivered to decision makers so that it is comprehensible and acceptable. Research such as this focuses on communication processes and how they fit into decision making.

An output of research along the lines of this study would be techniques and guidelines for the presentation of various kinds of information useful in resource allocation decisions.

- E To identify what roles various publics do and can play in recreation resource allocation decision processes.

The information derived from this descriptive research deals with understanding the state of the public involvement system and what future states it might take.

- F To identify the roles that different recreation suppliers (public and private) might play in recreation resource allocation, given changes in economic and behavioral systems.

Research such as this would lead toward the specification of current and potential future roles for the various recreation suppliers. It would provide information necessary to deciding how gaps in the recreation opportunity spectrum might be fulfilled, if that is deemed desirable.

- G To determine how recreation suppliers can more effectively (than currently) coordinate their planning. Several descriptive and experimental studies seem possible under this objective.

An output of this type of research would be knowledge of effective techniques for fostering cooperation among recreation suppliers.

- H To determine what trade-offs exist between recreation and other uses of land. A current sub-question might be, what are the benefit-cost implications of trading recreation for other land uses given a current scarcity of energy products?

Research on this topic is fundamental to developing optimum allocation strategies.

- I To identify what elements or factors are necessary in a system for long-term recreational planning.

The product from this type of conceptual research would be development of a system(s) for recreational planning.

- J To determine what means are available to maintain options for the future and to determine the relative costs of the various means.

An output of such investigation would be to identify which strategies for plan implementation would be most effective and efficient in protecting options.

- K To determine how, given different recreation resource allocation processes, a full range of the recreational opportunities can be provided. A fundamental part of this study would be determining the relevant full range for any region.

This type of study would lead to drafting guidelines for utilization of resource allocation processes to insure development of a full spectrum. It may also lead to identification of "problem" processes or ways to modify allocation processes.

- L To identify the nature of the political system which underlies the allocation of recreational resources. It is likely that this research would involve investigation of the relationships between Federal, State and local governments as they pertain to recreation.

The basic output of this investigation would be an understanding of how allocation of recreational resources operates in the political system and how allocation might be influenced.

- M To determine the roles played by the policy and the legal systems in the allocation of recreational resources.

Identification of the degree to which policy and legal systems are constraints on recreation resource allocation would be a product of this investigation.

Many of the projects identified above have several possible studies within them. There are also several approaches to determining and identifying the items,

processes, and information suggested. The resource allocation topic has been one of considerable concern for some time, especially by economists. There is still, however, much which needs to be done, some of the priority items are identified above.

MOTIVATION TO ENGAGE IN LEISURE-TIME EXPERIENCES AND RESULTING SATISFACTIONS AND BENEFITS

SCOPE AND REGIONAL RELEVANCE

The general question, "What motivates leisure-time behavior and what satisfactions and benefits are therefrom derived?" underlies both participation in leisure activities, and management and planning for leisure resources. An answer to this question implies an understanding of the behavioral basis of demand. This implies, in turn, understanding motives, preferences, satisfaction, and substitutability for the purposes of prediction, resource allocation, site and area planning, and management.

Three of the more important questions within this issue involve definition of leisure experiences, substitutability, and displacement of users. The first question deals with determining how recreationists and others define their leisure experiences. Just what are the important attributes of hunting, backpacking, and snowmobiling experiences which recreationists seek. The second question deals with finding out what experiences are substitutes for what other experiences. In the economists' terms this is centered on determining elasticities of demand and substitute commodities. Given scarce resources, this is an extremely important issue and one which becomes more important as mobility is curtailed during periods of energy deficit or periods of high rates of inflation. Finally, the third question deals with changes in the clientele of a site or area caused by changes in the site's (area's) character or use patterns.

This "motivation" issue is related to the Region, but less so than the previous issues. The major tie is that since the Region contains abundant recreational opportunities, it provides a good laboratory in which to study motives to engage in selected leisure experiences. Also, because of the Region's resources, engagement in some activities such as skiing, wilderness recreation, wild river adventure, and national park tourism might best be studied within the Region.

SOLUTION CRITERIA

In the last few years an attack has been made on components of this issue. Sociologists, psychologists, and economists have been engaged in this work. Several sociometric and psychometric tools have been designed to work on the issue and this development of measurement tools

needs to continue. Some of the other work that has been done has dealt with typing recreational experiences and placing them into groupings or typing participants and relating groupings of them to activities. Notable accomplishments have been achieved in the building of this typology for recreation in wilderness, big game hunting, and use of off-road recreational vehicles. In addition, these efforts have led to burgeoning interest in and beginning studies on the substitution and displacement questions.

The subject matter of this issue is highly researchable and highly needed in administration, but it is likely to take a long time for problem solution. Determining the motives for engaging in leisure experiences and specifying the relationship between the satisfactions and benefits derived from various leisure experiences could provide insight on the extent to which scarce environmental resources might be substituted for by opportunities that are relatively more available. Such information could help guide public policies regarding resource allocation. Moreover, it would help define those activities that provide nonsubstitutable satisfactions and benefits which are derived from resources that may be subject to irreversible actions (e.g., wilderness). Furthermore, management can use this information in determining what opportunities (for experiences) to produce. Finally, motivational information is relevant for decisions about employment of management tools such as design, pricing, rationing, and others and about the response of users to these measures.

The long time-frame estimate for problem solution in this issue is derived from a couple of observations. There is need to borrow or develop conceptual frameworks onto which behavioral data can be hung for interpretation. Until this is done, consistently useable information for the planner and manager will not be produced. The second point is that more measurement tools are needed before some leisure experiences can be examined. The instruments developed so far are activity-experience specific and are not suitable for other activities.

To help solve problems some administrative re-arrangement would be helpful. Two problems are identifiable: (1) the lack of sensitivity and expertise in the behavioral sciences in public land management agencies and private suppliers and (2) the unclear linkages between researchers and administrators which occur with every form of leisure research but are particularly acute here because of (1) above.

SOLUTION EXPERTISE

While all of the areas of expertise examined do have a role to play in this issue, clearly, expertise in behavioral sciences must play a dominant role. Sociologists, psychologists, and economists take this issue as one focus of their disciplines.

PROBLEMS WITHIN ISSUE

Several problems can be identified for this "motivation" issue. Some are listed below.

- A. To determine the relevant attributes of people's definitions of leisure experiences. This is the fundamental problem of any producer, to determine what products people want to purchase.

The output of this research would be an indication of how people define leisure and recreation experiences. This information is useful in deciding what activities and facilities to produce and what management tools to employ.

- B. To identify what leisure activities are substitutes for each other.

The information produced by this research would be valuable in planning for future needs as well as in responding to system changes (e.g. energy shortage).

- C. To identify non-leisure substitutes for leisure experiences.

Research on this topic is important in identifying ways to reduce impact on overused recreation facilities and areas. Also, it is important for planning whether or not to meet projected deficits for recreation activities.

- D. To determine the economic values of leisure experiences to participants.

Successful research on this topic would mean derivation of values for recreation which could be equated to values for other commodities.

- E. To identify the psychological values of leisure experiences which are represented by economic values.

An output of this research would be identification of the psychological benefits received from engagement in recreation and other leisure activities. Such information might be useful for decision making about publicly supplying recreation opportunities and for resource allocation decisions.

- F. To determine how understanding people's motivation toward recreational experiences can be applied to recreational planning and management.

Undertaking this kind of conceptual research will reveal the kinds of information that are useful for planning and management and how this information might be incorporated into decision making.

- G. To identify the behavioral theories most useful for interpreting recreationists' behavior for planning and management purposes.

From such an investigation as this, frameworks for structuring data collection and interpretation would emerge. These are necessary to achieve some comparability among studies of recreational behavior and between recreation studies and other behavioral analyses.

- H. To identify the relationship between understanding motivation to recreate and the prediction of recreation activity.

This type of research is necessary to determine whether or not prediction can be enhanced through measurement of people's motivation to engage in recreation activities.

- I. To identify the common factors which lead to changes in participation in recreation.

Knowledge of these factors would aid prediction of participation response under changing conditions as well as indicate how changes in participation might be induced.

- J. To identify and integrate what is already known about recreational behavior and can be applied in planning and management. This research is highly integrative and conceptual.

The product of a study such as this would be the integration of existing knowledge into a package useable by decision makers.

- K. To determine how recreational administrators might be educated to a level of expertise in social sciences to understand behavioral information and its uses. This is essentially a question of education.

Techniques for education in behavioral science, given the particular needs and roles of recreational administrators, would be the product of this analysis.

- L. To identify and develop methodologies to obtain behavioral information useful for planning and management.

Development of methodologies for data collection and analysis is necessary for more advanced behavioral analysis. The output would be development of borrowing of these methods (from other uses).

While there are many additional projects which could be identified within the "motivation" issue, these identify the

breadth of the topic. Understanding the issue is necessary for solving many problems in recreation and leisure, and many of the above projects are directly linked to other recreational issues such as impacts from recreational activity and resource allocation.

RELATIONSHIP AMONG ADMINISTRATORS AND RESEARCHERS IN IDENTIFYING RESEARCH PROBLEMS AND IMPLEMENTING RESEARCH FINDINGS

SCOPE AND REGIONAL RELEVANCE

Leisure research findings are not being applied. To this can be added, researchers and administrators are not communicating about problems which need research. There are several likely causes of these problems among which are institutional and budgetary arrangements which limit contacts between researchers and administrators: the day to day problem orientation of administrators and the longer time horizon operations of researchers, the types and requirements of various outlets for research reports, the professional recognition given for reporting results to peers, communication channels which are difficult to locate (such as a university report series), and a lack of workshops designed for the exchange of ideas and techniques between researchers and managers. Even when results are implemented, it takes considerable time before knowledge is extended outside the sponsoring administrative body. A joint effort by researchers and administrators needs to be directed at improving the flow of information. This flow of information should be about problems needing research and about implementation of research findings. Then, it is important that the implementation is monitored to determine effects.

This "administrator/research" issue is not specific to the Rocky Mountain Region, but since a considerable amount of leisure research has been conducted in the Region and because of the extensive federal holdings in the Region (the Federal Government sponsors a lot of leisure research), it is a particularly acute problem.

SOLUTION CRITERIA

The state-of-the-art for this issue is relatively weak. There is a paucity of documentation of this problem, although it is discussed extensively. There have been few attempts to make consistently better links (a notable exception is the efforts of the U.S. Forest Service wilderness research group) and to monitor the effects of communication efforts. For the most part, the literature on leisure research does not address this issue.

Many problems within this issue can be researched, but for other problems solutions might come through administrative rearrangement. Some things which can be

researched are the means to overcome this communication and action-oriented problem. New forms of communicating research results to planners and managers must be developed, tried, and monitored. Trying out these means should be treated as experiments. Research can also be conducted on means to gain implementation of research results. For the problem of identifying items needing research, administrative rearrangements may prove quite fruitful. The need is to foster arrangements that make it easy for researchers and administrators to communicate about management and planning problems frequently.

Solution time for many of the problems can be short (less than 2 years). If the problem is recognized now and efforts are started, a closer working relationship can be achieved in a relatively short time.

SOLUTION EXPERTISE

Behavioral science, political science, and administrative expertise are most closely linked to this administrator/researcher issue. However, all areas of expertise have a role to play, since the problem is one of researchers of any discipline communicating with leisure resource administrators.

PROBLEMS WITHIN ISSUE

Seven problems within this issue are listed below. These represent some of the diversity involved within the issue.

- A. To determine the institutional arrangements which can be made to increase contacts between researchers and administrators.

The output of research such as this is identification of institutional rearrangements needed to enable better administrator/researcher communications.

- B. To determine whether or not a research clearinghouse could be effectively used by administrators.

By conducting an experiment such as implied in the objective, the effectiveness of the clearinghouse idea could be evaluated.

- C. To determine whether or not a research clearinghouse (or some other entity) could be used to sponsor forums through which administrators and researchers exchange ideas and experiences.

Again, an experiment is implied. The output would be an evaluation of the effectiveness of the forum idea as a communicative facilitator among administrators and researchers.

- D. To identify the possibility of funding researchers to spend time with administrators.

An output here is the knowledge of whether or not funding can be made available for researcher/administrator contacts given existing budgetary situations. Another output might be identification of possible budgetary rearrangements to enable more contacts.

- E. To identify the possibility of funding administrators to become members of research teams.

Investigations along the lines suggested in the objective should produce knowledge of current funding policies and opportunities, as well as indicate how budgetary matters might be re-arranged to facilitate administrators' involvement in research.

- F. To determine the extent to which recreational research findings are being incorporated into experiences of college students who are potential recreational planners and managers.

Research such as this would indicate whether or not college education is an effective route for bringing research results to administrators.

- G. To identify the characteristics of recreation researchers who refuse to become involved with recreation administrators (or vice versa).

An output of this research might be guidelines for hiring researchers if the desire is to encourage researcher/administrator contacts.

While this "administrator/researcher" issue is not specific to recreation and leisure research, it is relevant. Non-cooperation would undoubtedly mean implementation lags and possible rejection of findings. Also, without cooperation research would not be as able to serve the needs of administrators.

MANAGEMENT SYSTEMS APPLICABLE TO INSURING PRODUCTION AND MAINTENANCE OF OPPORTUNITIES FOR RECREATIONAL EXPERIENCE

SCOPE AND REGIONAL RELEVANCE

As managers of recreational areas have attempted to deal with problem such as congestion, site impact, and multiple objectives for management, systems for managing recreational areas have begun to emerge. Researchers have picked up on these emerging systems and conceptually developed some of them while investigating possible management tools and consequences associated with them.

One management system, based on what might be called carrying capacity, has conceptually received considerable

attention. However, there are many more questions to be asked and answered about the system. Problems of integrating physical-biological changes with changes in the visitor's experience remain a problem. Another area concerns the effects of increased use on the types and levels of satisfaction derived by visitors. Closely related to these problems are strategies to manage within constraints of carrying capacity. Several techniques for rationing (pricing, quota systems, licenses, etc.) and visitor dispersal (trail and road development, information provision, site assignment, etc.) are available to the manager but have not been systematically applied and tested for their effects on the resource, the user, or the managing organization (whether private or public).

Going beyond the carrying capacity approach, which seems to be well suited to reserved areas (wilderness, wild rivers, and national parks and monuments), there may be other management systems which have a different focus and are applicable to other situations. Other possibilities need to be investigated.

While this issue is not unique to the Rocky Mountain Region, some of its aspects can probably best be studied there. Particularly relevant are questions of the carrying capacity of reserved areas such as wilderness, national parks, and wild rivers. Additionally, some attention to recreational management systems for general "multiple use" lands and fluctuating water bodies (e.g. Lake Powell) is pertinent.

SOLUTION CRITERIA

For this "management" issue, the state-of-the-art, as evidenced by the amount and diversity of published literature, is at a moderate level. Conceptualization of the issues has gone rather far, particularly for recreational management in wilderness, use of the southwest deserts by off-road recreational vehicles, and big game hunting. Many of the tools and techniques for studying problems within this issue are developed (though some are activity or area specific) and only need slight modification for use in new situations. Actual investigation of many of the problems has not been undertaken, however. Also, little attention has been directed toward any system other than the one emphasizing carrying capacity.

Both researchability and administrative need are high for this issue. The problems within the issue demand conceptualization and testing of the management systems in an experimental fashion. Additionally, the applicability of various management tools can be tested in controlled experiments. For administrators, the need is for workable management systems for different situations in recreational management and for determining what are effective management tools and strategies given their impacts on the resources, the users, and the administrative body.

Solution time for this issue is moderately long. Some of the conceptualization can be completed relatively easily, while specific experiments must be spread over time and space. It is also unlikely that many of the problems can be solved by administrative rearrangement.

SOLUTION EXPERTISE

Behavioral science, political science, natural and physical science, and administrative expertise are most closely associated with the problems within this issue. This is clearly an area where administrators can play a significant role in the research process by helping conceptualize possible systems of management, helping researchers perform experiments by implementing management techniques, and in alerting researchers to experimental possibilities that arise because they (the managers) are going to change management actions or adopt new techniques.

PROBLEMS WITHIN ISSUE

Like the other issues so far discussed, there are many problems which fit within this issue of management systems. These are listed below.

- A. To characterize the functional relationship between the elements which make up the recreation management decision process (system) which focuses on carrying capacity as an integral part of the system.

The conceptualization proposed here is necessary to understand and test the applicability of a carrying capacity based system. The output is an explicit statement of the systems model.

- B. To identify the implications to recreationists and administrators of management decisions which are made from a carrying capacity based decision process.

From this kind of "impact" research, the benefits and costs of utilizing a system for management decisions can be evaluated.

- C. To determine which management tools (pricing, development, etc.) are applicable to management derived from a carrying capacity based decision process. Numerous experiments are possible within this problem area.

An output of a series of experiments utilizing different management tools as treatments, on different activities in different areas, would be guidelines for the application of management tools.

- D. To determine how physical-biological elements can be combined with elements of a recreationist's experience when a decision process based on carrying capacity is utilized. This study is both conceptual and empirical.

An output of a study such as this would be a method for calculating carrying capacity which recognizes both physical-biological and social factors.

- E. To determine the applicability of a decision process based on a carrying capacity utilized for recreation management in wilderness to other reserved areas such as national parks and wild rivers.

From this research would come an evaluation of the suitability of utilizing one management system for all reserved areas.

- F. To determine whether there are management decision processes, other than carrying capacity based, which are applicable to management of recreation.

Primarily this would be a conceptual study which might lead into field testing studies. The output would be identification of management systems applicable to recreation.

- G. To determine the implications of various management systems for the supply of a variety of recreational opportunities.

This study would indicate whether or not individual management systems tend to eliminate options or limit the supply of specific recreational opportunities.

- H. To determine the applicability of various management systems to different kinds of recreational opportunities such as wilderness, semi-developed areas, amusement parks, and others.

A product of this investigation would be the matching of management systems to specific recreational opportunities.

- I. To identify the various information inputs necessary for each management decision process.

This conceptual study would lead to guidelines for the collection of data needed in management decision processes.

- J. To determine the time and budget requirements for the utilization of various management decision processes.

A study such as this would lead to identifying the efficient management decision processes from an organizational viewpoint.

- K. To determine the personnel skill and educational requirements necessary for the utilization of various management decision processes.

An output of this investigation would be guidelines for

the training required of personnel to utilize a specific process. This might help to specify how personnel might be trained to utilize a process.

This area of "management systems" for recreation has emerged from the work undertaken on recreational carrying capacity. While that work has proceeded for the last decade, little attempt has been made to conceptualize other systems or to investigate whether or not other systems are used. It is not clear, also, to what extent a carrying capacity based process is used. Studies focusing on some of the objectives listed above would help to clarify these issues.

DEFINITION OF NATURAL RESOURCES BY DIVERSE PUBLICS AND RESULTING RESOURCE VALUES

SCOPE AND REGIONAL RELEVANCE

The issue centering on the question, "How do various publics define natural resources?" has direct relationship to the three regional criteria (water, energy, and federal land) but is less regionally specific than the other issues because it is relevant to any place. It has a more general connotation than the other issues primarily because it has to do with people's perceptions. However, it does have regional significance since part of the uniqueness of the Rocky Mountain Region stems from its vast natural resource base. Due to public control of much of this resource base, public perception of natural resources is very important. Questions dealing with preservation, exploitation, esthetic enhancement and deterioration, and reservation of areas all fit within this issue. The issue includes decisions about land use and resource production within the Region.

An interesting set of questions for this issue can be built around the several cultural groups found within the Region. If various Indian groups, Mexican-Americans in the Southwest, agriculturalists on the plains, Mormons in Utah and adjacent areas, and other identifiable groups define different resources as "goods," there are significant implications for resource and environmental management in the Region.

SOLUTION CRITERIA

The state-of-the-art with regard to this issue is moderate to low. Few investigations have been made regarding people's perception of resources, though there have been a few analyses by geographers and resource economists which have addressed some problems. Techniques need to be developed to deal with the problems posed by this issue. Survey and experimental methods are both possible routes to delve into some of the value oriented problems listed below.

Many facets of the issue can be researched, and for planning purposes, administrative need is high for answers from research. For management, administrators have

somewhat less need to study the issue. Questions regarding human values toward various resources and toward philosophical positions (preservation, exploitation) are researchable. Questions dealing with esthetic values, while not easy to handle, also lead to some forms of research, particularly in psychology and economics.

Solution time for this issue is relatively long and the issue does not necessarily imply problem solutions through administrative rearrangement. The time frame is long because there are many fundamental problems to be examined and because, in many cases, research tools need to be developed.

SOLUTION EXPERTISE

Geography, behavioral science, and political science are the areas of expertise most closely linked to this issue. The issue regards the perception of space and resources and the meaning of this perception.

PROBLEMS WITHIN ISSUE

Several problems which fit within this issue are listed below. It is an extremely varied issue containing a multitude of specific problems and possible projects.

- A. To identify the values which lead to preservation and exploitation of natural resources. Some of the information needed could be gleaned from literary sources, while some collection of primary data would be necessary.

Understanding of the origins of values about resources and the influential factors modifying values would come from a series of studies focusing on the above objective.

- B. To determine how various publics define reserved resources such as wilderness, wild rivers, and national parks.

Both planning and management decisions for the recreational use of reserved resources could be greatly enhanced by knowledge of people's perception of these resources.

- C. To determine public perceptions of the amount of land reserved as wilderness, wild rivers, and national parks and monuments.

Essentially, this research would be input to determining the quantity of reserved area desired by various publics.

- D. To determine the perception of the "goodness" or "badness" of wilderness, wild rivers, and national parks and monuments relative to home location.

An investigation like this would enable an evaluation of expected impacts from land reservation as well as provide input for the development of weighting systems for evaluating public involvement in resource decisions.

- E To identify the relationship between personal mobility and definition of resources.

Essentially this investigation would indicate whether or not definitions of resources change with increases in affluence, changes in resource supply which affect mobility, and other changes in life style.

- F To determine the values held by various publics relative to modification of landscapes.

This research would provide a base for understanding values underlying the perception of landscapes and the changes in landscapes due to environmental management.

- G To determine how reactions to landscape modification vary with factors such as location of modification, home location, and the situation in which the modification is encountered.

Research of this type would lead to determining the conditions under which people perceive landscape modifications as having negative impacts or enhancing the landscape.

- H To identify existing means and develop new means, if necessary, to evaluate landscape modifications. Both conceptual and empirical projects are possible under this objective.

An output of these studies would be techniques for the evaluation of landscape changes.

- I To identify the relationship between landscapes and recreation experiences.

From research on this topic, the importance of landscape esthetics in recreational experiences would be identified. Additionally, information relative to the environmental settings in which recreation is preferred would be gained.

- J To identify and develop means to inventory natural resources given various publics' resource definitions. It is likely that both different resources and various attributes of the same resource are important to different publics.

Research on this topic would lead to development of resource and public specific inventory techniques.

- K To identify the relationship between place perception and resource definition. One item under this heading is whether or not people view resources differently according to where they, (both the people and the resources) are located, such as in the high plains, Rocky Mountains, or Salt River basin.

Two products of this research would be an indication of what geographic area makes up a resource region and what information is needed to understand people's responses to environmental and resource changes.

In no way do the potential projects listed above cover the fullness of this issue. There are many area and culture specific questions which might be asked. Particularly important at this time are questions dealing with energy minerals. Coal extraction from the plains of Montana to Navajo lands in Arizona, oil shale development in Utah, Wyoming, and Colorado, geothermal development throughout the Region, and other similar issues are all of concern.

CONCLUSION

The task was defined as identification and examination of researchable issues dealing with leisure, recreation, and tourism which are relevant to open-option lands of the Rocky Mountain Region. Seven broad issues were identified dealing with (1) impacts on the environment; (2) recreationally oriented communities; (3) resource allocation; (4) motivation to recreate; (5) relationships among administrators and researchers; (6) recreational management systems; and (7) definition of natural resources. Each of these issues was examined for scope, regional relevance, solution criteria such as researchability and administrative need, and solution expertise most likely to be of value in research on the issue. Additionally a list of some problems within each issue was developed and each problem briefly discussed.

What was not done was to construct a list of problems which are place and time specific. While many specific problems require solution, most can be built into research programs designed for the issues we have identified.

What we have suggested and what is needed is the building of research programs around each of the issues identified. For both short- and long-term views, programs should be started now so that some problems are solved, and for others a base of information and understanding is built. Tomorrow is not too late to begin. But, if we wait until tomorrow we will lose some options.



F. RURAL RESIDENTIAL DEVELOPMENT

Task Force Leader: Anne S. Williams

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TASK FORCE REPORT:
IMPACTS OF RURAL RESIDENTIAL DEVELOPMENT

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SUMMARY

"Rural residential development" has been defined to mean residential development which occurs predominately in rural areas. For purposes of this report, it does not include development within or adjacent to metropolitan areas. In an attempt to evaluate research needs concerned with the impacts of rural residential development, we have focused upon three major types of residential development: (1) individual, dispersed development; (2) second-home developments in subdivisions (vacation-home subdivisions); (3) "new towns" or the revival of "old towns" for recreational purposes; and (4) "New towns" or the revival of "old towns" for other, industrial based purposes (e.g., coal mining, energy production, etc.) Although existing research data focus primarily on the impacts of recreational or retirement-oriented residential development, the reader must recognize that the impacts of recreation-oriented new communities are similar to the impacts of other industrial-related "new towns" in the Rocky Mountain Region. Accordingly, the implication of available research findings have application to all types of "new towns" regardless of the purpose for which the community was developed.

A four-phase approach has been employed in this analysis: (1) Phase I--inventory of existing research data; (2) Phase II--determination of relevant policy issues and associated research gaps; (3) Phase III--development of a priority ranking of research gaps; and (4) Phase IV--examination of the implications of these findings for decision making and implementation processes.

The task group recommendations concerning the most pressing and relevant research agenda items are listed in the body of the report.

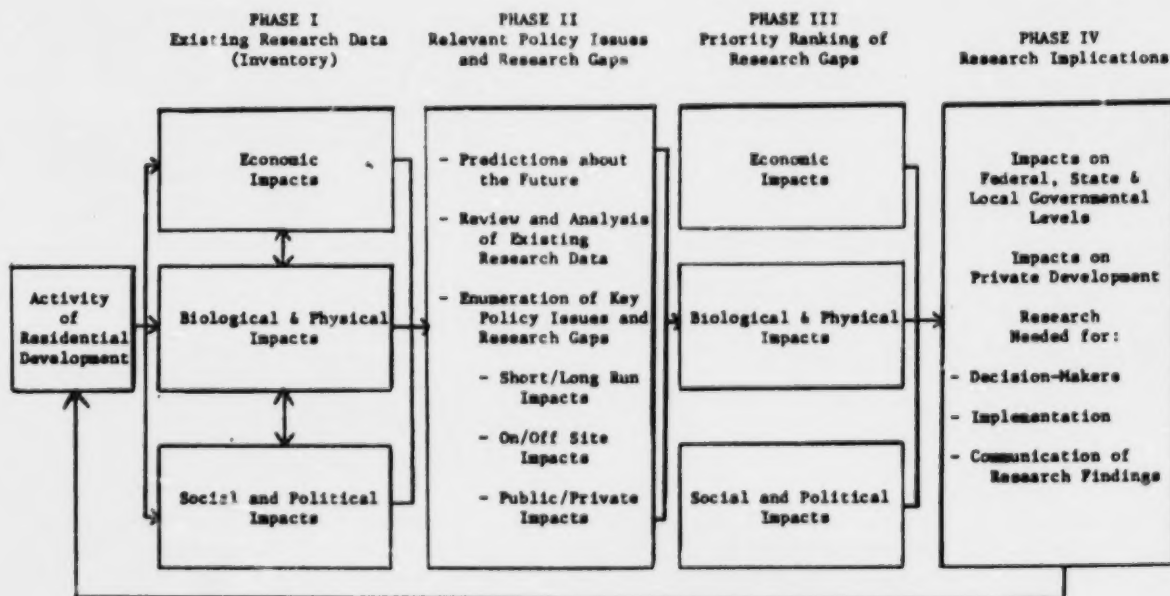
INTRODUCTION

Analytic Approach

The diagram illustrates the analytic approach used to: (1) inventory existing research data (Phase I); (2) examine relevant policy issues and associated research gaps (Phase II); (3) develop a priority ranking of research gaps (Phase III); and (4) outline the implications of these findings for decision making and implementation processes (Phase IV).

FIGURE I

IMPACTS OF RESIDENTIAL AND SECOND HOME USES



Phase I. Our approach was to review current research evidence on the impacts (costs and benefits), over time, of the four types of residential development outlined above. Members of the task group formed three subcommittees to address the following:

1. **Economic Impacts**--to examine impacts of product demand (including demands for services, both public and private), employment impacts (including multiplier effects¹), and tax base (including sources of revenue and expenditures of revenue).

2. **Biological and Physical Impacts**--to examine impacts upon the biological and physical environment as well as esthetic (visual) impacts, and to address the questions of natural resource utilization and depletion, resource re-use, and resource-use conflicts (e.g., loss of agricultural land to rural residential development).

3. **Social and Political Impacts**--to examine the impacts upon: local, State, and Federal governments, land-use practices (including zoning, performance bonding, etc.), and social or cultural (lifestyle) impacts.

Phase II. This phase included: (1) consideration of forecasts about the future; (2) an analysis of the existing research data concerning the impacts of residential development in rural areas; and (3) enumeration of the key public-policy issues and research gaps concerning residential development, including short- and long-run impacts, and on- and off-site impacts of public and/or private developments.

Phase III. Formulation of a priority list of the most prominent policy-relevant research gaps concerning "new towns" and other rural residential development was undertaken in Phase III. Enumeration of specific priority research questions was attempted, with particular attention to: (1) economic impacts; (2) environmental (biological and physical) impacts; and (3) social and political impacts.

Phase IV. The final step included estimation of the impacts of alternative public-policy decisions upon local, State, and Federal levels of government and upon the private sector (including private developers, vacation-home and other residential purchasers, and other concerned groups). Particular attention was directed to: (1) assessing research needs of decision makers; (2) methods of implementing land-use plans; and (3) communication of research findings to public and private interest groups.

¹"Multiplier effect" is defined as "the magnified impact that changes in investment and spending have on total income." For example, money spent on a new plant increases the income of contractors and workers, increases the income of merchants with whom workers trade, increases the income of merchants' suppliers, and so on. (From McGraw-Hill Dictionary of Modern Economics, 1973.)

PHASE I--INVENTORY OF EXISTING RESEARCH DATA

Economic Impacts

The inventory of the existing research data includes a review of the literature on those known research methodologies that have application to the economic impact of residential developments in rural areas. This includes a review of previous economic studies related specifically to residential homes in rural areas, as well as studies where the subject matter may have been somewhat different but where the analytical approach has application to the problems of residential development.² Examples of these research approaches include, but are not limited to:

Determinants of Residential Home Demand. Empirical research has been conducted on consumer demand and the determinants thereof. Such methodologies could be applied to general research questions relating to the demand for residential development in the rural areas of the Rocky Mountains³. Little historical trend data are available on nonagriculturally oriented rural residential (particularly vacation-home) construction and purchase. As a result,

existing methodologies must be modified or new ones developed to determine and evaluate relationships between various economic indicators and demand, for use in forecasting potential future pressures on the land for these uses.⁴

Infrastructure⁵ Requirements. Vacation-home developments and "new towns" in rural areas represent a special form of residential growth, and as such, will create needs for public goods and services, (for example, water supply, road maintenance, and police protection) and for private goods and services such as groceries, gasoline, and recreation. However, because of the nature of vacation-home usage, the demand for these public and private goods and services will often be seasonal or cyclical depending upon the recreation orientation of the development; and, because of the nature of industrial-based "new towns," planning for service needs must be based on a finite time period to coincide with the predictable life span of the town's industry.

A review of available literature indicates that some research has been done and methodological approaches are available. However, the research emphasis in this area is usually on the demands for goods and services from the private sector and the objective is primarily to determine the multiplier effect. Data about effects of vacation-home

²Two basic research reports that indicate the data requirements and methodology needs related to vacation-home--and other recreation--research are: (a) Robert R. Nathan Associates, Inc., 1966, *Recreation as an Industry*, Appalachian Res. Rep. 2, Appalachian Reg. Comm., Washington, D.C. vi & 131 p. and (b) URS Research Company, 1971, *Recreation Potential in the Appalachian Highlands: A Market Analysis*, Appalachian Res. Rep. 14, Appalachian Reg. Comm., Washington, D.C., vii & 237p.

³For purposes of this report, the Rocky Mountain states have been defined to include Arizona, west Texas, New Mexico, Nevada, Wyoming, Idaho, Utah, Colorado and Montana.

⁴Studies which have been conducted to provide base data on such research or to create methodological approaches are exemplified by the following:

(a) Digges, Mary Jane, "The Booming Leisure Home Market," *Arizona Review*, 19(8-9):6-9. University of Arizona, Tucson, 1970.

(b) Leaming, George F., "Future Residential Development in the Southwest" *Arizona Business*, 19(5):8-16. Arizona State University, Tempe, Az., 1972.

(c) U.S. News and World Report, "Leisure Boom: Biggest Ever and Still Growing," 72(16):42-45, 1972.

(d) U.S. Bureau of the Census, 1970 Census of Housing, *Detailed Housing Characteristics*. HC(1)-B1. U.S. Department of Commerce, Washington, D.C., 1972.

(e) U.S. Bureau of the Census and Forest Service, *Second Homes in the United States*, Current Housing Report H-121, 16. U.S. Department of Commerce, Washington, D.C., 1969.

(f) Thompson, James C., and Gordon D. Lewis, "Rural Residential Development on Private Land in the Mogollon Rim Area of Arizona," Chapter VI, *Mogollon Rim Land Use Plan*, Reg. 3., USDA Forest Service, Albuquerque, N.M., 1973.

⁵"Infrastructure" is defined as "the foundation underlying a nation's or a community's economy (e.g., transportation and communication systems, power facilities, and other public services) and upon which the degree of economic activity depends." In some cases the term "infrastructure" also refers to social characteristics of a population such as educational level, social attitudes, industrial skills and administrative experience. (From McGraw-Hill Dictionary of Modern Economics, 1973.)

developments and industrial-based "new towns" on the demand for, and the supply of, public goods and services are almost completely lacking.

The impact of rural residential growth and development on the costs and revenues of local governments is an area needing review and study. There is no large body of knowledge or bibliography on the effect of development on taxation, but some research reports are beginning to appear.

At least, one study has examined the increase in property values and local tax revenues resulting from the conversion of agricultural land to vacation-home subdivisions and the sale of individual lots, but there is little evidence of research into the increased demands for public services and the potential increased costs to local governments for supplying these services.

Brown concluded, in Pennsylvania, that: (1) transforming 1,275 acres of cropland and pasture land into a second-home community brought added income to local business, increases in tax revenue, and little change in demand for government services; (2) financing produced interest income, but not to a large extent locally; (3) maintenance expenditures were expected to create much local income; (4) the rise in tax revenues with an increased tax base should more than cover the cost of additional services demanded of local taxing districts; (5) the demand for school facilities was not appreciably increased so long as the development remained primarily second home; and (6) little economic activity was displaced as, in Pennsylvania, other agricultural land was available to make up for production lost from development.⁶

In Minnesota, local governments with seasonal homes have a greater capacity to provide goods and services than those without, but county roads cost more for counties with seasonal homes, and highway construction needs increase with occurrence of seasonal homes--poor roads are a complaint of seasonal homeowners. However, school districts with seasonal homes do not spend more per pupil than those without.⁷

Western rural areas have usually welcomed subdivisions as a means of increasing revenues.⁸ However, some problems have been created by inactive land held for speculation, alteration of watersheds, and demand for community services in remote locations. One study concluded that: "Once demands are made for urban services to the more remote subdivision areas, the costs are likely to be much more than the tax revenue generated by these subdivisions."⁹

Dumper found that the increase in the property tax base and revenues resulting from the growth of communities in agricultural areas was mostly used to improve the school systems.¹⁰ However, developments or communities with large family units usually do not yield enough tax revenues to pay for the increased demands on the school system.¹¹ Property taxes on vacation homes are usually assessed on the same basis as permanent residences, but vacation home owners add no costs to the school system as their children are usually educated elsewhere. Thus, it is generally assumed that vacation-home developments create more tax revenues than tax costs so they are beneficial to local governments. However, this advantage may be offset by other costs for which research results and definitive data are lacking.¹²

⁶U.S. Dept. of Agriculture, Economic Research Service, *Economic Impact of Second-Home Communities: A Case Study of Lake Latonka, Pa.*, R.N. Brown, Jr., November, 1970 (ERS-452) Washington, D.C.

⁷Snyder, R.W., "Local Governments and Policy Implications of Seasonal Home Ownership in Rural Areas," Agricultural Experiment Station, University of Minnesota, St. Paul, Minn., 1970.

⁸Workman, John P., et al., *A Taxpayer's Problem: Recreational Subdivisions in Utah*, Utah State University, Logan, Utah, 1973.

⁹Johnson, Morris E., *Utah's Subdivisions Problem*, Bureau of Community Development, University of Utah, Salt Lake City, Utah, August 1973.

¹⁰Dumper, Thomas A., "The Impact of Urbanization on Watershed Development," *Journal of Soil and Water Conservation*, 21:24-26, Jan.-Feb. 1966.

¹¹*The Use of Land, a Citizen's Policy Guide to Urban Growth*. A Task Force Report sponsored by the Rockefeller Brothers Fund. Ed. by William K. Reilly, New York: Thomas Y. Cromwell Co., 1973 (esp. Chapters V, VI, VII).

¹²The existence of research, or a lack of it, is best exemplified by the following reports: (1) Hulbert, James, "Fire Problems in Rural Subdivisions," 1972, *Am. For.* 78(2):42-27, 47, and (2) Allen, Martin J. and James P. Waltz, *How Safe is Mountain Well Water?* Colo. State Univ. Res. 22(2):10-12., Colo. State Univ., Ft. Collins, Colo., 1972.

A further problem relating to taxation is that revenues from recreational development appear to be adequate to cover the public services required, but most of these revenues go to the state in the form of sales taxes and do not always get back to the county in which the recreational activity or second-home development occurred. This can create an imbalance between county income and demands for county services.¹³ It is evident that, in some cases, the costs of providing services exceeded the revenues generated from such developments, while in others, data indicate the reverse.

Economic Benefits. Methodologies are available for assessing the economic impacts of rural residential developments. Research has been conducted in specific geographical areas and a variety of economic impacts have been determined. However, the basic procedures for analyses have been the same, ranging from economic base studies for small areas to the more sophisticated Leontief input-output analyses.¹⁴ The needs here are to develop, for the Rocky Mountain West, the inputs for these analytical procedures and determine the numerical relationships (coefficients) between the various areas of local and regional economies affected by rural residential developments.¹⁵

Biological and Physical Impacts

Rural residential development and industrial-based "new towns" have a direct impact on the natural environment in their utilization of land, air, water, plant, and animal resources. Much of this impact is adverse to a high quality natural environment.

While all forms of development and use affect the tenuous balance of fragile aquatic and terrestrial ecosystems, the following are examples of specific impacts due to residential development:

(1) Esthetic degradation due to roads, utility lines, signs, buildings, solid waste; enhancement through landscaping, and so on.

(2) Modification of watersheds due to construction of roads and buildings, removal of vegetative cover with resulting erosion, increased run-off due to increase of impervious areas, and contamination of surface and ground water.

(3) Disruption of wildlife through destruction of habitat, interruption of migration routes, and harassment by people and domestic animals.

In the Rocky Mountain West there is particular concern about the impact of rural residential development on highly productive agricultural land. Obviously, if rural residential developments were to make use of sloping sites, land above flood plains, or other land not suitable for farming, there should be no conflict between rural residential development and agricultural use of the land. While slopes are not ideally suited for farming, except for grazing and terracing for orchards, housing on slopes permits the kind of scenic views important to those seeking to spend part or all of their time in rural areas. An ideal land-use policy would permit both agricultural and residential uses. There are examples of such compatible uses in Switzerland and in other parts of the world. Even the use of small, residential estates in prime agricultural land is not incompatible with farming providing the land not occupied by dwellings is cultivated. However, the problem in the Rocky Mountain West is that land speculation and lot sales of large subdivisions have removed good agricultural land from production and left it idle for years.

¹³Moore, Arthur L., "Reservoir Recreation and Local Economic Growth," *Economic Studies of Outdoor Recreation*, ORRRC Study Report 24, 1962, USGPO: Washington, D.C.

¹⁴Leontief, Wassily W., et al., *Studies in the Structure of American Economy*, Oxford University Press, New York, New York, 1953.

¹⁵Examples of research and methodology used in evaluating the economic benefits of vacation-home developments are as follows:

- (a) Richey, Clyde W., "Value and Property Taxes of a Second-Home Subdivision," *Land Economy* 48(4):387-392, 1972.
- (b) Bleck, Erich K., "Merchandising Remote Subdivision Lots in Southern Arizona," *Arizona Review* 21(8-9):10-15. University of Arizona, Tucson, Az., 1972.
- (c) National Association of Home Builders, "Vacation Homes in the United States," *Economic News Notes*, Monthly Report 19(6):3 Washington, D.C., 1973.
- (d) Brown, Richard N., Jr., *Economic Impact of Second-Home Communities, A Case Study of Lake Latonka, Pa.*, ERS-452. Economic Research Service, USDA, Washington, D.C., 1970

Research comparing the impacts and potential trade-offs of alternative land uses has been conducted to develop justifications for regulating development with emphasis on matching the resource to the proposed land use. The basic assumption behind Environmental Impact Statements is that social, environmental, and economic relationships are known and can be measured. However, consistent methodologies have not been developed that can be used in evaluating residential-environmental relationships for rural areas.¹⁶

Although much research and observation have been carried out, the results are scattered among a multitude of disciplines. Thus, the problem is not so much a lack of data as the: (1) multiplicity of disciplines involved; (2) lack of contact, communication, and coordination among them; and (3) lack of an adequate framework for dealing with environmental impacts. However, there is no dearth of expertise to approach individual components of the environmental effects of residential and "new town" development in rural areas. For example, significant knowledge exists in the basic sciences which allows the appraisal of environmental impacts associated with residential developments, and quite a few technologies exist for minimizing residential-related pollution and its effects on the environment; however, this knowledge needs to be more fully utilized in applied research, and new technologies need to be developed. Interdisciplinary endeavors concerned with environmental impacts are beginning, but require greater stimulation.¹⁷

Given widespread development of recreation-oriented second homes, and the likelihood of accelerated development of "new towns" related to coal and energy production in the Rocky Mountain Region, the ecological "carrying capacity" of the land is of major importance.

Much of the research to date has been directed at developing techniques to assess the inherent capabilities of the land resource. Of interest in this regard are a number of attempts which have been made to define and analyze landscape patterns in ecological terms.

G. Angus Hills developed a system of classifying land for potential use and management based on land forms and ecological factors.¹⁸ The system breaks larger regions of land into consecutively smaller units of physiographic differentiation (macroclimate, land form, geology, soils, and microclimate) to identify the smallest unit with homogeneous landscape features. Each unit was then ranked in terms of its potential productivity to sustain agriculture, forestry, wildlife, recreation, or other uses of land. The primary purpose of Hills' analysis is to evaluate whether present or future uses of the land are ecologically suitable, economically feasible, and socially desirable.

Philip H. Lewis developed a system for identifying and analyzing the patterns of unique perceptual qualities, both natural and cultural, within the landscape.¹⁹ His objectives were to identify, preserve, protect, and enhance the most outstanding intrinsic values so that introduced man-made values could be developed in harmony with the qualities of the natural resource. From case studies in Wisconsin, Lewis concluded that surface water, wetlands, and significant topography were major elements in the midwestern landscape that offered beneficial esthetic, working, living, and recreational qualities. These major natural features combined to produce linear patterns, which he termed "environmental corridors." Lewis contends that a system of design based on a region's landscape patterns can blend all forms of development into an ecologically sound and functionally integrated system without destroying the natural quality of the landscape.

¹⁶The Literature available is best exemplified by the following:

- (a) Udall, Morris K., "Land Speculation, Investment in the Future, or Downpayment on Dust." Congressional Report XI(3). 2nd District Arizona, 1972.
- (b) Schmiedemann, Ivan W., Alvin B. Wooten, and William W. Sartta, *Land Use and Rural Development*. Texas Agri. Prog. 18(4): 17-19 TAP 640. Texas A&M University, College Station, Texas, 1972.
- (c) Soucir, Cory, "Subdividing and Conquering in the Desert," *Audubon* 75(4):26-35, 1973.
- (d) Krutilla, John V., Charles J. Cicchetti, A. Myrick Freeman III, and Clifford S. Russel, *Observations on the Economics of Irreplaceable Assets*. Resources for the Future, Washington, D.C., 66p., memo, 1970.

¹⁷For example, an interdisciplinary team of researchers at Montana State University has been conducting a comprehensive assessment of the impact of the Big Sky of Montana resort development with funding from NSF-RANN. See Jezeski, et al., "An Overview of the MSU-NSF Gallatin Canyon Study," Research Monograph #1, Montana State University, Bozeman, June, 1973; and Nielson, et al., "Environmental Impact Assessment: The Gallatin Canyon - Big Sky Development," *Journal of Soil and Water Conservation*, Sept. Oct., 1973.

¹⁸G. Angus Hills, 1961, "The Ecological Basis for Land Use Planning," Ontario Dept. of Lands and Forests, Research Rep. No. 46, 204 p.

Ian L. McHarg theorizes that the landscape reflects the interaction of a complex system of biological processes that constitute natural determinants of land use.²⁰ He states that locating urban development and determining its form and growth should be based on ecological principles instead of the present system of economic determinism. McHarg developed an "ecosystem inventory" based on the concepts of plant communities, association, and succession to identify natural features and processes as they relate to historical geology, climate, physiography, hydrology, and soils. These data on natural processes are then applied to land-use planning by systematically separating individual processes, identifying their limiting factors, assigning values to them, and finally establishing land-use policy.

The U. S. Geological Survey is currently conducting a multi-faceted pilot study to provide earth science data increasingly needed by decision makers in southeastern Idaho. Special-purpose maps will depict active seismic zones, volcanic centers, slopes and slope stability, rock properties, various geophysical measurements, regional groundwater levels, various hazards, geochemical data, and other geologic data required for complete analysis of land resources.²¹

While architecture is an art with many expressions and philosophies to guide its application, architecture when related to the environment lends itself to certain guidelines aimed at producing buildings with minimum visual disturbance to the natural setting. If it can be accepted that buildings, roads, dams, signs and other works of man should harmonize, blend with, and enhance their surroundings, then guidelines for design can be helpful. Indeed there are such guidelines being used in several communities in the Rocky Mountain Region.²² These could be assembled and reviewed, and form the basis for general guidelines for use throughout the Region.

For specific subdivisions, two notable studies exemplify the use of evaluations of ecological factors as constraints to land development. The Lily Lake project in central Wisconsin used natural landscape features as a basis for

designing a recreational subdivision.²³ Using an evaluation of soils, geology, topography, hydrology, and vegetation, the authors produced a subdivision design that permitted high quality residential developments without destroying the major natural features and amenities of the area.

A second study used an integrated biophysical analysis to determine land-use capability on a large real estate development southeast of Helena, Montana.²⁴ Biophysical components of the landscape (e.g., soils, slope, present and potential vegetation, hydrology, geology, climate, and wildlife habitat) were mapped in detail. Then, based on this knowledge of the land resource, recommendations of the land use and development potential of specific parcels in the subdivision were made. This process preceded the design platting phase thereby permitting the developer to preserve and maintain the natural values and esthetics in harmony with the overall development.

The above represent isolated examples of efforts toward grappling with the problem of ecological "carrying capacity." There is a need for investigation and synthesis of available methodology.

Social and Political Impacts

A review of the literature and available information revealed the following:

1) Most materials are case histories or statistical studies of vacation-home ownership and/or "new towns."

2) Very few studies address the question of the social impacts associated with the development of vacation homes and/or "new towns" in rural areas.

3) Impacts of second home are better known than impacts on second homes. (General things like more money, inflation, increased building costs, land-use controls, increased leisure time, better highways, etc., have impacts on.)

¹⁹U.S. Department of Interior, National Park Service, 1969, "Regional Design for Human Impact -- Appendix B -- Aesthetics and Cultural Values," Prepared by Philip H. Lewis, Jr. & Associates, An Appendix for the Upper Mississippi River Comprehensive Basin Study, 104 p.

²⁰Ian L. McHarg, 1969, *Design with Nature*, Natural History Press, Garden City, New York, 197 p.

²¹Pilot Environmental Geologic Study of Eastern Snake River Plain Region, S.E. Idaho, Rocky Mountain Environmental Branch, U.S.G.S., Denver, 1972.

²²For example: Brown, G.E., *Eagle County Master Plan*, County Planning Commission, Eagle County, Colorado, 1973.

²³M. Atef Sharkaway and James A. Graaskamp, "Inland Lakes Renewal and Management Demonstration -- Lily Lake Forest Recreational Environ.," Environmental Awareness Center, School of Natural Resources, Univ. of Wisconsin, Madison, 1971.

²⁴Evan Denney and Steven A. Carlson, "Biophysical Resource Analysis as a Basis for Land Development," Land Use Planning Short Course, University of Montana, Missoula, July 1973.

4) Current methods of development do not appear to encourage the building of second homes; for example, developers often do not carry out proposed schedules for the provision of services, and there is a trend toward excessive speculative land sales and purchases. Proposed changes in regulation should slow land sales but encourage building.

5) The literature concerning land-use practices covers two general areas of concern: (a) descriptions of the impacts of uncontrolled land use, and (b) descriptions of regulatory policies for land-use control.

The Demand. There is an apparent increasing demand for rural residential development in scenic areas of the Rocky Mountain states. This demand appears to be creating a reincarnation of suburban American in scenic rural settings. Indicators of this growing demand for our land resources include:

1) Inflation, dollar devaluation, and scandals have made investors look to alternative forms of investment--by far the most popular of these investments seems to be land (which some say offers the buyer rare psychological opportunities to speculate and still feel protected, with the prestige of a property-holder).

2) The demand for land is increasing more rapidly than the population.

3) The growing concern over the energy crisis is resulting in greater pressure to develop the vast coal reserves of the Rocky Mountain Region, with the result that "new towns" will be growing up in the sparsely settled rural areas of the Region.

4) The average price of land under FHA-mortgaged houses is up 80 percent since 1963, while lot size is down from 11,000 to 7,000 square feet.

5) Between 1960 and 1970, developers bought up three million acres of the country's 1.1 billion acres of farmland. According to a spokesman for the American Land Development Association, there were 2,800 developers registered with HUD (as of early 1973), which is 35 to 40 percent of all developers, and these 2,800 developers represent 3,800 to 4,000 developments.²⁵ Registered developments average about 4,000 acres and represent in excess of 1,700,000 total lots, which is also just about 35 to 40 percent of the business. HUD anticipates that well over five million lots exist "and will soon be registered."

Rising affluence and increased leisure time particularly among the more affluent of the vacation and recreation home market, have contributed to two recent trends: (1) greater mobility of vacation-home owners, and (2) frequent purchase of multiple vacation-home sites. The recent growth of the time-shared condominium is evidence of the increased speculative investment in vacation homes and of the "multiple destination" philosophy of the highly mobile recreation and investment-oriented affluent classes.

A Utah study reported that Utah's subdivision activity is nearly equal to that of California, although the population of Los Angeles alone is eight times that of the entire State of Utah.²⁶ Also, the population of counties in Utah with the largest subdivision activity has increased only modestly, indicating that most subdivision is not for primary home building. At present, no effective land-use control exists. The Utah Real Estate Division has the responsibility of investigating lands offered for sale and making a public report, but is not authorized to deny permits to sell even though there are critical problems with a subdivision. In many cases, water supply, drainage, roads, and fire protection are nonexistent or inadequate. Additionally, speculative use of land is encouraged by low taxes on undeveloped lots.

Pressure for a sound land-use policy is likely to increase in the foreseeable future. We have seen the effects of unplanned, ugly, inefficient developments--areas that have been developed in an environmentally unsound manner -- and with the apparent growing demand for vacation homes and "new towns" in the rural areas of the Region, we can expect that the "social issue" of the 1970's and perhaps beyond, will be "land use."

Private enterprise maximizes this demand. Land sales are booming, subdivisions of rural acreage are being platted, new communities are being planned and built, and old communities, such as Telluride, Colorado, are being rejuvenated. Developers are selling lots to investors as well as to prospective home builders, and in many locations most sales are for purposes of speculation. Additionally, there is a growing trend for foreign investment in land speculation ventures as well as vacation home developments.

Regulation. To cope with this feverish activity, which often threatens to degrade the very esthetic qualities of the environment which helped create the desire for recreation-oriented development in the first place, laws have been passed and others are under consideration at all levels of government.

²⁵Remarks to the annual meeting of the American Land Development Association, New Orleans, 1973, by Mr. John Dennon.

²⁶Workman, John P., et al., *A Taxpayer's Problem: Recreational Subdivision in Utah*, Utah State University, Logan, Utah, 1973.

At the Federal level the Council on Environmental Quality, Securities and Exchange Commission, Environmental Protection Agency, Internal Revenue Service, and Office of Interstate Land Sales Regulation (through HUD) have some degree of control over such development. The United States Forest Service has also limited ski-lift capacity on public land to control commercial residential development at base facilities. However, governmental control of land use raises some critical and difficult legal issues. For example, the Fourteenth Amendment to our Constitution provides that no State shall deprive any person of life, liberty, or property without due process of law. Critics of pending national legislation to control land use (the Land Use Policy Act and the Flood Disaster Protection Act) argue that these bills would deprive persons of their property rights.²⁷

The several States of the Rocky Mountain Region have enacted some laws in the field of comprehensive planning, public health and safety, environmental protection, building construction, business practices, and land use. However, local and state governments have not effectively organized to confront the very real problems associated with rural residential development. As a result, land-use control has become a national concern, and one to which the Federal Government is becoming increasingly responsive. The proposed Land Use Policy Act of 1973 (SB 268) and the Flood Disaster Protection Act are two examples of this growing concern at the Federal level.

Local governments affect development through zoning ordinances, design control, health and safety regulations, building codes, land use planning and performance bonding requirements, and subdivision regulations. But, in the field of second-home development there is a lack of controls and enforcement of existing laws. Most legislation at the State and Federal levels has been passed in reaction to private-sector development abuses.

One study analyzed laws governing land practices in California, with the following conclusions.²⁸ Two basic laws govern subdivision activity in California: (1) Subdivided Land Act and (2) Subdivision Map Act. The former is basically a disclosure law and puts no restrictions on the developer, except that he must give special

information to be included in a public report which is to be made available to the prospective buyers. No penalties are applied to those who fail to follow the Act, unless they have first ignored a restraining order. Also, according to this authority, this law is not vigorously enforced. The Subdivision Map Act places responsibility for subdivision regulation with local units of government, requiring local units to have supplemental ordinances regarding local subdivision. The purpose is to coordinate subdivisions with local plans and insure improvement of public areas without excessive taxation. This researcher also notes that local ordinances are usually so liberal and so many exceptions are granted that this Act has been very ineffectual. Enforcement of these laws are the business of the Department of Real Estate, who Commissioner must have had five years experience in the real estate field. He must relinquish his license temporarily, but the seven advisory commissioners need not. This authority concludes that this entrenched special-interest representation on the Commission has served to maintain developmental abuse.

A second study, in Utah, found a total lack of uniformity in local government procedures involving approval, building-permit issuance, and implementation of related ordinances concerning subdivisions located in unincorporated areas.²⁹

Social Impacts. Some developments have contributed positively to some segments of society by providing employment opportunities and by meeting the needs of recreation-seeking persons as well as meeting demands for residences in rural areas. Likewise, recreation enterprises and "new towns" have often had positive impacts on existing communities by providing employment and earning opportunities for native inhabitants, and in general, by boosting the local economy.

Much has been written about new towns such as Columbia and Reston which could prove useful even though these towns lie beyond the Rocky Mountain Region.³⁰ More useful would be on-going studies of such developments as Lake Havasu City, Vail, and Aspen, Colorado. Studies now in progress on the impacts of the Gillette and Rock Springs, Wyoming, and Big Sky of Montana Developments should provide valuable additional information.

²⁷For example, see the report prepared by the U.S. Council on Environmental Quality, *The Taking Issue: A Study of the Constitutional Limits of Governmental Authority to Regulate the Use of Privately Owned Land Without Paying Compensation to the Owners*. Fred Bosselman, 1973, Superintendent of Documents, Washington, D.C.: USGPO.

²⁸Fellmeth, Robert C., *Politics of Land*, New York, Grossman, 1973 Chapter 8.

²⁹Johnson, Morris E., *Utah's Subdivision Problem*, Bureau of Community Development, Univ. of Utah, Salt Lake City, Utah, August, 1973.

³⁰For example, Community Research and Development, Inc., *Columbia, A Presentation of the Officials of Howard County, Maryland*, Baltimore, Md., 1964 and Breckenfield, Gurney, *Columbia and the New Cities*, Ives Washburn, Inc., New York, NY.

The review of existing research data must also consider the impact on society resulting from committing irretrievable resources to such developments. One very obvious social-impact cost of current subdivision practices is the massive fragmentation of rural land ownership which may represent a formidable cultural barrier to future constructive urbanization or other land use. Acquisition of land for substantial new development or other uses when needed will be costly and difficult.

PHASE II--RELEVANT PUBLIC-POLICY ISSUES AND ASSOCIATED RESEARCH GAPS

Analysis of the existing research data and enumeration of the key public-policy issues and research gaps associated with residential development in rural areas have been undertaken in this phase. More specifically, this phase represents an analysis of the literature concerning the economic, biological and physical, and social and political impacts of rural residential development and an enumeration of policy-relevant research gaps. However, prior to this analysis and enumeration, we have attempted, by extrapolating from current regional and national trends, to make some forecasts about the future.

Forecasts About the Future

One method of developing forecasts about the future is to assume that current trends will continue. However, alternative futures can be envisioned by changing one's assumptions. For example, implementation of a land-use policy act, a severe economic recession, or other unpredictable alternations of current trends would change the nature of future rural residential development.

For illustrative purposes, we have assumed that current trends will continue and have developed forecasts about the future on this basis. However, the reader may wish to make different assumptions and develop his own forecasts about the future.

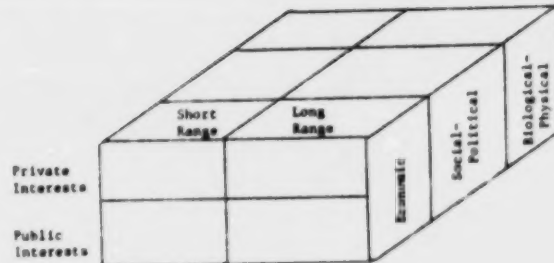
Although some believe the energy shortage may have an impact on the continued heavy demand for second homes,³¹ energy-related new town growth is presently increasing at a remarkable level. A review of existing and predicted social and political trends leads one to reasonably expect an increased demand for the following by the year 1990:

- 1) More vacation homes in rural areas.
- 2) More resort hotels in rural areas.
- 3) More campgrounds and motor-home park sites in rural areas.
- 4) More rural land for speculation.
- 5) Public use of public land for recreation activities.
- 6) Public use of private lands (e.g., for fishing access, hunting, etc.).
- 7) Private use of public lands (e.g., lease, special-use permit, etc.).
- 8) Exchange and/or sale of public lands for private development.
- 9) More service industries to support vacation-home housing.
- 10) Improved health services in rural areas.
- 11) Improved schools in rural areas.
- 12) Subsidized housing for employees required by service industries.
- 13) Light manufacturing industry in rural areas.
- 14) Research industries in rural areas.
- 15) Competition for commercial land uses in rural areas (e.g., due to competition for the same lands among extractive industries, agricultural and ranching industries and the vacation-housing industry).
- 16) Recreational land resources, including wilderness areas, wildlife refuges, wild rivers, etc.

On a broad scale it is reasonable to expect pressures for conservation of energy and other natural resources. We can also reasonably expect pressures for raising the income levels of the poorest members of society. There will also be changes in the working habits of society; flexible work schedules and shorter work weeks will likely be adopted by more and more industries and organizations, resulting in increased demand for recreation, vacation, and second homes. Likewise, given continuing inflation, increasing property taxes, and the present gasoline shortage, it is

³¹See particularly, "Demand Slowing for Second Homes," *New York Times*, January 20, 1974.

reasonable to expect an increasing trend for conversion of second homes into first homes and a high potential for increased competition among first and second home builders for resources. In addition, there is likely to be greater pressure: (1) for alternative, more efficient modes of transportation to, from, and within, second-home communities and "new towns" in the Region; (2) for well-planned, environmentally compatible, vacation-home developments and "new towns"; (3) on Federal, State, and local governments for land-use planning; and (4) for vacation-home and other residential development to accommodate a wider range of income levels.



Public-Policy Issues

Analysis of the literature indicates that, in general, the most prominent public policy issues concerning rural residential development and development of "new towns" include: (1) irretrievable commitments of resources such as prime agricultural lands and open space; (2) energy use and natural resource use generally; (3) residential siting and "new towns" development in rural areas--what are the most environmentally and socially compatible residential settlement patterns within the Region, and how can we minimize the adverse social and environmental impacts of these developments; (4) how can we minimize the social, environmental, governmental and public service impacts resulting from the "boom-bust" cycle characteristic of "new town" development; (5) the compatibility of the apparent desire for residential developments in rural areas with the goal of maintaining an ecosystem balance; (6) how much vacation-home development and "new town" development is needed in rural areas of the Region, and how much can we afford while still satisfying competing demands for the same natural resources; (7) what are the best methods of dealing with land use, and social and environmental conflicts which result from extensive rural residential development on small parcels of privately owned land adjacent to public holdings; and (8) what are the most effective and socially acceptable methods of regulating potentially damaging land uses in rural areas of the Region (land taxation, easements, land-use planning and zoning, etc.)?

Enumeration of Key Public-Policy Issues and Associated Research Gaps

Key issues related to recreational home development and use and the development and use of "new towns" in rural areas may be considered here within the framework of the following matrix:

Enumeration of policy issues or problem areas within the above framework may serve as a means of identifying key research gaps but does result in considerable overlap. Specific problems may have both long- and short-term implications, or may lie within both the domains of private and public interests, or may have biological and physical as well as economic, social and political impacts.

The following enumeration of policy-relevant research gaps is organized into three sections: (1) economic; (2) biological and physical; and (3) social and political. The attempt here has been merely to enumerate the most critical policy-relevant research gaps, rather than listing each of the items by priority. The reader may wish to consider the research gaps listed here within the framework outlined above.

Economic Issues and Research Gaps. Existing research shows that the build-out rates in most recreational subdivisions are very slow, creating significant problems for the host community, developer, and lot consumer. In some areas, inflated lot prices have been included in tax assessment determinations with the effect of raising the property taxes of permanent local residents and/or agricultural landowners. Agriculture remains significant in many rural areas, but is being impinged upon by recreational subdivisions. A single rural residential development or a "new town" in the heart of an agricultural area can potentially destroy agricultural use by creating heavy tax burdens resulting from higher land values created by urban-type uses.

In some rural areas preferential tax incentives have been adopted to keep farms as farms. About thirty-three States have preferential or deferred taxes for agricultural lands. Yet in some States, subdivision activity is encouraged by increase tax assessments. This results in added pressure to subdivide in order to bring a high return on the land.

The most notable policy-relevant research questions which must be addressed are:

- 1) Under what circumstances do vacation-home and "new town" developments generate sufficient revenues to cover the costs of providing needed community services?
- 2) What are the economic effects and social costs, both to the developer and consumer, of time delays on vacation-home and "new town" developments? How can such costs be minimized?
- 3) What are the consequences of various methods of funding housing for employees hired to service and maintain second-home developments?
- 4) What are the consequences of various forms of taxation and assessment on unimproved lots?
- 5) What are the minimum municipal services incumbent upon the different types of second-home and "new town" developments? What is the optimal time period for the provision of these services?
- 6) What are the spillover effects of recreational and residential lot development on surrounding environments, and under what circumstances are these externalities³² positive or negative?
- 7) Many observers believe that recreational lot and leisure housing developments generate greater revenues through property taxes than they consume in public services, especially in the early years of development. However, the cost/revenue picture may change substantially over the years, especially if the initial infrastructure is insufficient to service the development and also if considerable conversion of leisure homes to permanent homes takes place—a phenomenon which has been substantial in some areas. How do current research data on economies of scale in the provision of services apply to second-home communities? What is the economically optimum size and density for efficient service delivery?
- 8) What are the consequences of alternative methods of providing municipal services to second-home communities and to "new towns" (e.g., developer, county or local municipality, home owners' association)?
- 9) One clear problem resulting from land speculation is tax delinquency. Lots sold to a number of individuals not intending actually to build a vacation home creates this problem. Property taxes are often not paid on these held lots, and the publication of tax delinquency rolls and owner searches are expensive and create unnecessary administra-

tive burdens for counties. What are the social, economic, and environmental costs associated with people buying lots but not building on them, and how can these costs be minimized?

10) What effect will the conversion of second homes into first homes have on community service requirements (for example, health and educational needs)?

11) What are the social and economic costs and benefits of: (a) present land-exchange policies which result in the trading of public and private lands; (b) policies on special-use permits which allow commercial recreational development on public lands?

12) How will the future demand for second homes be affected by: (a) the conversion of second homes into first homes; (b) technological innovation which provides city amenities to outlying areas; (c) efforts to make urban areas more attractive and livable; and (d) the present and growing concern over the energy crisis?

Biological and Physical Issues and Research Gaps.

Environmental degradation may assume many forms. The principal types of degradation that can result from second-home and "new town" development and use, and which require public-policy consideration include: (1) chemical and bacterial contamination of streams, lakes, and groundwater by nutritive materials, toxic substances, and macro- and microscopic organisms introduced through solid waste, litter, domestic sewage, waste waters derived from commercial establishments, or chemicals spread over land, such as pesticides; (2) physical contaminants in water including sediments derived from soil erosion caused by home and road construction, and particulate matter in waste waters. Change in water temperature also constitutes a form of pollution in its effect upon evaporation and surface water biota; (3) gaseous contaminants and particulate matter emitted into the air during the construction and use of rural residences and "new towns," (from automobile motors, construction activities, fireplace smoke, etc.); (4) noise—motor vehicles, power boats, construction and industrial activities, etc.; (5) solid wastes, litter soil erosion, and other forms of land degradation; (6) visual pollution caused by construction of signs, highways, buildings, powerlines, and other man-made features which interfere with view of the natural landscape; and (7) impacts on native vegetation and disturbance of wildlife habitat and migration routes.

The key policy-relevant research gap associated with vacation-home and "new town" development is how to

³²"Externality" is defined as "the burden or benefit imposed on parties other than the consumer and/or producer of the good because of, and for no other reason than, the consumption and/or production of that good."

minimize the adverse environmental impacts which often accompany such developments and, by so doing, satisfy the human values served by vacation-home and rural residential living. In order to achieve this goal, the following research questions are suggested:

1) More refined methods of analysis of all environmental impacts are needed, including better methods of analyzing impacts upon esthetics, scenery, and open space.

2) What are the spillover effects of vacation home and "new town" development upon the surrounding environment, and how might adverse impacts be minimized?

3) More innovative, less polluting modes of transportation (both public and private) to, from, and within, second-home and "new town" developments need to be discovered and considered.³³

4) Resource managers need systematic procedures: (a) for having access to, and assessing the wide range of existing resource inventory data so that duplication of data collection and analysis can be minimized; (b) for establishing generally an acceptable measure of what constitutes environmental pollution; and (c) for continued monitoring of environmental impacts.

5) More research is needed to assess the effects of second-home and "new town" development upon land, water, air, plants, and animals. (For example, what is the fate of specific contaminants introduced into water and soil and their effects on animals, plants, and man?)

6) Research is needed on recycling of natural resources and waste materials associated with second-home and "new town" development (e.g., re-using nutrient constituents of sewage as well as water).

7) Research is needed on the effects of noise associated with construction and use of second-home and "new town" developments, including levels of tolerance, effects on health, and methods of eliminating noise.

8) New ways of developing second-home communities, "new towns," and modes of living that are less wasteful of resources need to be discovered and considered.

Social and Political Issues and Research Gaps. The most pressing policy-relevant research questions in this area concern the following:

1) What are the conflicts between native population, on the one hand, and second-home owners and residents of new rural towns, on the other hand, and how might these conflicts be minimized?

2) What are the positive and negative consequences of alternative methods of controlling land use (for example, covenants as compared to ordinances)?

3) What are the human values served (social benefits) by vacation-home development and use?

4) What recreational, social, and other "quality of life" opportunities are lost to the public by committing resources to second-home development? Who pays these social costs and how might such costs be minimized?

5) What are the costs and benefits of developing vacation-home communities (on both private and public lands) for public use, through rental and leasing, rather than private ownership?

6) No regional data exist which reliably describe the distances traveled to and from second homes in the region, nor the number of second homes, by location in the region, nor the proportion of time such homes are in use (occupancy rates). This absence of information renders it virtually impossible to accurately predict the short-term pressures on transportation systems or the impact of current gasoline shortages on vacation-home development and use.

7) The use of time-shared condominiums foster a system of absentee ownership in many recreational and second-home communities. There is need for comparative community studies to systematically assess the impacts of absentee ownership upon the local community structure upon the community decision making processes.

8) Surface and ground water use by second-home communities and "new towns" for domestic consumption, waste disposal and dilution, irrigation, and various recreational purposes may conflict with other residential uses, with other prior private uses, or with public uses of these waters. Resource managers need some means for identifying potential water-use conflicts, before they occur, and for resolving water-use conflicts once they exist.

³³Of interest are the following two publications which consider the need for alternatives to automotive highway transport rural areas: Montooth, Charles, "Who Needs Branch Lines?" *Trains*, February, 1972, and Montooth, Charles, "The Need for Scenic Railways," *Trains*, March, 1974.

9) There is need to review and compare all existing (and pending) legislation which has any effect on second, vacation, and recreation homes and on "new towns," and to determine the impacts of, and gaps in, Federal, State, and local regulations for second-home and "new town" development. Additionally, what are the impacts of fragmented decision making on regulation and control of second-home and "new town" development?

10) There is a need to analyze where the second-home industry is going; that is, what kinds of developments are they providing, why and what are the impacts of these changes (from bare lots, to improved lots, structures on lots, PUD's, new communities)?

11) What are the social impacts of alternative private land uses (e.g., recreational land development, development of "new towns," recreational use without development, mining, timber production, etc.)?

12) "New town" development creates two problems, neither of which have been satisfactorily addressed: (a) how can we most effectively provide for the short-term social and public service needs of construction personnel required by single industry "new towns" and (b) what are the most effective means of planning for the eventual demise of single industry "new towns"?

13) What are the legal rights of landowners, how do they perceive their "rights," and how does this affect land-use legislation?

14) What are the legal rights of public regarding land-use control for second-home development and the development of "new towns" in rural areas?

15) Is it politically, socially and economically feasible to limit development on private lands adjacent to public holdings by means of access regulations, land exchanges, purchase, special use permit, and so on?

16) Given the growing concern at the national level for systematic land-use planning and pending Federal legislation, will the issue of "home rule" introduce serious conflicts among State, local and Federal Governments?

17) Do the citizens of the Rocky Mountain Region have unique values, attitudes behaviors, and desires? What are the effects of second-home and "new towns" related growth and change on these regional values?

PHASE III--PRIORITY RANKING OF RESEARCH GAPS

Formulation of a priority list of the most prominent policy-relevant research gaps concerning "new towns" and other rural, residential developments was undertaken in this phase. Since all research gaps enumerated were considered "high priority," an attempt was made to develop a mechanism for distinguishing the relative importance of each of the research questions and of assigning levels of priority.

Priorities were assigned based upon consideration of the importance of the research question to the Rocky Mountain Region, including the long- and short-term impacts, on- and off-site impacts, and impacts upon public and private decision makers and public and private sectors of the population. Four types of priority were assigned.³⁴

1. Highest Priority

This research: (a) will provide for the solution of important, current regional problems; or (b) will indicate how to prevent environmental damages (particularly those relating to irreversible effects); or (c) is expected to have a high probability of payoff; or (d) will consider the weakest links in complex systems where there are interrelated parts.

The key policy-relevant research gap associated with rural residential and "new town" development is how to minimize adverse environmental impacts which often accompany such developments and, by so doing, satisfy the human values served by vacation home and rural residential living.

Recommendations. In order to achieve this goal, the following research questions are suggested as those with the most critical or highest priority:

1.1) In the Rocky Mountain Region, what will be the expected level of second-home and "new town" development by the following years: 1980, 1990, 2020? Where will the greatest pressures for these new residential units be felt? (For example, how will planned highway construction affect siting of second homes, and how will mining and energy production plans affect "new town" development in the Region?) General research inventory needs associated with this question include: (a) inventory of available scenic and recreation land; (b) inventory of available surface transportation; (c) inventory of towns in scenic areas and description of their physical, economic, and social condition; (d) inventory of gateway transportation facilities; (e) inventory of the Region's urban centers along with industry, employment, and population data and projections; (f) inventory of available water supply and determination of competing water resource uses; (g)

³⁴Priority assignment adapted from guidelines by Jay M. Bagley, January 9, 1974, memo to RMER--Quest Group.

inventory of available energy supply; (h) review of land-use plans--existing and proposed; and (i) review of laws affecting land use.

1.2) Certain areas may not be considered available for development because of their unique environmental qualities or strategic locations; included among these are important agricultural lands, critical wildlife habitat, watershed areas, or other fragile or unique ecosystems. To assess the impacts of potential rural residential developments, more refined methods are needed for determining whether an area should be developed at all--what factors preclude development of any kind? These would include: (a) basic research necessary to assess more fully the effects of development upon land, water, air, plant, and animal resources. (For example, what is the fate of specific contaminants introduced into water and soil and their effects on animals, plants, and man?); and (b) more refined methods of analyses of all environmental impacts, including better methods of analyzing impacts upon esthetics, scenery, and open space. (This would necessitate examination of the availability and effectiveness of existing technical/professional capabilities for developing environmental impact analyses.)

1.3) Assuming rural residential development will take place, then there is a need to determine the best methods for early identification of the full potential and limitations of each individual land area for developmental purposes (existing natural amenities such as scenery and vegetation as well as hazards such as geological faults, avalanche paths, easily erodable and useable soils, lack of groundwater, fire danger, etc.)

1.4) There is need to review and compare all existing (and pending) legislation which has any effect on "new towns" and other rural residential development, and to determine the impacts of, and gaps in, Federal, State, and local regulations for such development. Research agenda items related to this analysis include: (a) what are the impacts of fragmented decision making on regulation and control of "new towns" and other rural residential development; (b) what are the positive and negative consequences of alternative methods of controlling land use (for example, covenants as compared to ordinances); (c) what are the most useful and appropriate techniques to insure protection of important recreation resources, open-space areas, and natural systems and to increase preservation for public use; (d) to what extent do regulatory deficiencies (that is, no controls, loose controls, or tight controls) affect vacation or residential home supply in rural areas or accelerate second-home and/or "new town" developments in a particular region; what are the intra- and inter-state variations; and (e) what types of land-use control would be most effective (for implementation, resource preservation, etc.), and what are the impacts (costs and benefits) associated with enforcement alternatives?

1.5) Analyses of the social-impacts of "new town" and other rural residential developments are sorely lacking. Past

studies, for the most part, have been fragmentary, incomplete, and retrospective accounts of social impact. Needed are integrated, complete, and interrelated accounts which are obtained before, during, and after the development of vacation-home communities and other "new towns" in order to learn how the dynamics of change affect people at all critical times in the development's history. Particular attention should be addressed to assessing the social impacts of such developments upon: (a) the community decision-making processes, including the leadership structure; (b) the life styles, psychological, and social needs of indigenous and immigrant populations, including impacts upon nearby ethnic communities and long-time area residents; and (c) the satisfactions, desires, attitudes, and behaviors of native populations, on the one hand, and second-home owners and residents of new rural towns, on the other hand.

1.6) What are the non-economic factors that may affect market demand within the time-periods 1980 to 2020, and which may alter existing predictive models? For example, how will the future demand for second homes be affected by: (a) the conversion of second homes into first homes; (b) technological innovation which provides city amenities to outlying areas; (c) efforts to make urban areas more attractive and livable; (d) the present and growing concern over the energy crisis; and (e) water availability and water resource conflicts?

2. Second Level of Priority

The solution of these problems: (a) will enhance the natural environment but not deal totally with irreversible questions; or (b) will have significant economic impact or high social value.

Recommendations. Among urgent policy-relevant research questions which must be addressed to improve land, air, and water resource decision making are the following:

2.1) Questions of appropriate resource utilization and resource-use conflicts have not been carefully addressed either by the scientific community or by resource managers. The most pressing resource-use questions relative to vacation-home and/or "new town" developments are: (a) what recreational, social, and other "quality of life" opportunities are lost to the public by committing resources to second-home development; who pays these social costs and how might such costs be minimized--this would require analysis of the competitive aspects of, and trade-offs involved in, public-recreation use as opposed to residential or second-home use; (b) what are the compatibilities and incompatibilities of vacation-home and/or "new town" developments with other uses of land; (c) what are the social impacts of alternative private and/or public land uses (i.e., recreational land development, development of "new towns," recreational use without development, mining, timber production, etc.); and (d) what are the impacts of privately supported second-home and "new town"

developments on the use of, and access to, nearby public lands, fishing streams, hunting areas, and associated public facilities?

2.2) Research is needed on the effects of noise associated with construction and use of second-home developments, including research on levels of tolerance, effects on health, and methods of eliminating noise.

2.3) In relation to waste-disposal systems, there are two research needs: (a) analysis of the effects of septic and field-drainage use under different conditions, including variables such as soil density, soil types, climatic conditions, geology, etc.; and (b) guidelines for intelligent selection among alternative waste-disposal systems (for example, methods, techniques, systems, and devices for re-use/recycling of solid wastes as well as treatment of liquid wastes).

2.4) What are the economic effects and social costs, both to the developer and consumer, of time delays on vacation-home and "new town" developments? How can such costs be minimized?

2.5) What are the costs and benefits of developing vacation-home communities (on both private and public lands) for public use through rental and leasing rather than private ownership?

2.6) The relationship between the tax revenues generated and the increased demand for, and cost of, local governmental services must be examined and analyzed for different types of rural residential developments. Among the most critical research topics associated with the tax cost/revenue relationship are: (a) how do current research data on economies of scale in the provision of services apply to second-home communities; (b) under what circumstances are tax incomes from rural residential developments sufficient to cover the short- and long-run costs of needed services, and under what circumstances are the financial costs of services required by such developments in excess of the tax revenues generated; (c) what are the minimum municipal services incumbent upon the different types of second-home and "new town" developments; (d) what is the optimal time period for the provision of these services; (e) what is the economically optimum size and density for efficient service delivery; (f) what are the consequences of alternative forms of taxation and assessment on unimproved lots; (g) what are the impacts of alternative methods of providing municipal services to second-home communities and to "new towns" (i.e., developer, county or local municipality, homeowners' association); (h) what are the consequences of alternative forms of taxation to provide community services to second homes and new rural

communities and what are the impacts and opportunities of revenue sharing; and (i) what are the implications of a fragmented system of taxation; that is, an ad hoc application of tax laws to rural residential developments?

2.7) What are the social and economic impacts (costs and benefits) of: (a) present land-exchange policies which result in the trading of public and private lands; and (b) policies on special-use permits which allow commercial, recreational development on public lands?

3. Third Level of Priority

This research: (a) will improve management efficiency; or (b) will have potential high payoff, but lower probability of success than priority items no. 1 or no. 2 above; or (c) will depend upon findings of other studies.

Much responsibility rests on public officials (county, state, etc.) for making affirmative decisions on residential projects with net positive benefits and non-affirmative decisions on those with net negative benefits. Such decision making could be improved if the research efforts would yield a simple "check-list" or "procedure statement" that would assist such decisions.

Recommendations. The following research questions are considered important and results from such research would significantly improve management efficiency by adding to our limited (but growing) knowledge concerning methods of land-use planning and implementation, and the social, political, economic, biological and physical consequences of land-use alternatives. Although many of the notable research gaps which have direct application to improving decision making are considered of third-level priority, this does not suggest that these research questions are of less urgency; but, rather, unless those questions with higher priority are first addressed, the following research questions cannot be adequately answered.

3.1) A structure for benefit/cost analysis of second-home and "new town" projects is needed. Indeed, it is recognized that economic benefits can be realized from these projects. At the same time, however, costs may be incurred through the foregone opportunities (opportunity cost³⁵) in the utilization of the site(s), through the public expenditures necessary to meet minimum standards, etc. Orderly planning will depend upon a workable benefit/cost framework.

3.2) To improve public-policy decision making, a related research need is the specification of a "decision model" based largely on the benefit/cost framework described above.³⁶

³⁵"Opportunity cost" is defined as "the value of the opportunities foregone when a particular option is chosen."

³⁶Such a benefit/cost framework, of necessity, would include consideration of social, esthetic, and other difficult-to-quantify impacts, as well as the traditional economic, biological, and physical impact analyses.

That is to say, it is assumed that certain second-home and "new town" sites and the development thereof are advantageous (benefits exceed costs). It is assumed, too, that some others are not advantageous.

3.3) Although considerable work has been done to develop and refine procedures or methods most appropriate for formulation of sound land-use plans, the "state of the art" needs greater refinement. Two general research gaps are apparent: (a) more sophisticated, less expensive methods of generating information for land-capability analysis and biological and physical mapping are needed; and (b) resource planners need some systematic procedure for assessing, having access to, and sharing, the wide range of existing resource-inventory data, so that duplication of data collection and analysis can be minimized.

3.4) There is need for development of more refined methods for management of open space and scenic environments with the intent of minimizing conflicts between second-home developments and public uses of surrounding recreational areas.

3.5) What are the legal rights of landowners, how do they perceive their "rights," and how does this affect land-use legislation?

3.6) What are the legal rights of the public regarding land-use control of second-home development and the development of "new towns" in rural areas?

3.7) The use of time-shared condominiums foster a system of absentee ownership in many recreational and second-home communities. There is need for comparative community studies to systematically assess the impacts of absentee ownership upon the local community structure and upon the communities decision making processes.

3.8) New ways of developing second-home communities, "new towns," and modes of living that are less wasteful of resources need to be discovered and considered. Research is needed on methods of recycling natural resources and waste materials associated with second-home and "new town" development (i.e., re-using nutrient constituents of the sewage as well as water).

3.9) There is a need to analyze where the second-home industry is going; that is, what kinds of developments are they providing, why, and what are the impacts of these changes (from bare lots, structures on lots, PUD's, new communities, etc.).

3.10) Development of techniques for implementation of land-use plans has been badly neglected. The most notable research needs concern: (a) more refined techniques for subdivision platting, review, and approval are needed, including consideration of the most effective organizational structures for systematic implementation; (b) how can local jurisdictions be assisted in formulating and implementing land-use plans; what combination of manpower, money,

and expertise is required for effective formulation and implementation of local plans?

4. Fourth Level of Priority

This level includes policy-relevant problems which: (a) should first have studies to explore feasibility of application or (b) have a relatively narrow range of applicability.

Recommendations. The following research agenda items are considered significant, and are included in this priority level not because they are of little importance, but because they either have a relatively narrow range of applicability or because the feasibility of conducting high-payoff research in these areas is yet to be tested.

4.1) Although some research addresses the question of the human values served by vacation-home development, more is needed. For example, what are the psychological and social needs served (social benefits) by vacation-home development and use?

4.2) Do the citizens of the Rocky Mountain Region have unique values, attitudes, behaviors and desires? If so, what are the effects of second-home and "new town" related growth and change on these regional values?

4.3) What are the consequences of alternative methods of improving housing for employees hired to service and maintain recreational and industrial developments?

4.4) What education and communication strategies would be most effective in increasing public understanding, and understanding by private industry, of the social, economic, and land resource trade-offs of alternative modes of second-home and "new town" development?

4.5) No regional data exist which reliably describe the distances traveled to and from second homes in the Region, nor the number of second homes (by location in the Region), nor the proportion of time such homes are in use (occupancy rates). This absence of information renders it virtually impossible to predict accurately the short-term pressures on transportation systems, or the impact of current gasoline shortages on vacation-home development and use.

4.6) What effect will the conversion of second homes into first homes have on requirements for community services (for example, health and educational needs)?

PHASE IV--RESEARCH IMPLICATIONS

Determining Positive and Negative Impacts

There is substantial evidence to support the conclusion that there are critical methodological problems in determining the impacts of "new town" and other rural residential developments. New avenues need to be opened and existing institutions utilized in order to encourage application of research findings by decision makers at the

Federal, State, and local governmental levels as well as the private sector level. Decisionmakers at all levels need to utilize all existing information in order to make sound judgments regarding pending and future legislation affecting second home use and the development of new rural communities.

As noted earlier, an analysis of the positive or negative impacts of existing land-use planning legislation upon the development of new rural towns should be made. For example, Figure II suggests a screening process to evaluate the impacts of past decisions on land-use upon the economic, biological and physical, and social and political characteristics of the environment.

To adequately examine the key public-policy issues concerning new residential development in rural areas, a systematic review should be conducted, in which the positive (+) and negative (-) impacts of current land-use decisions are assessed. Using this procedure, one could begin to address in a systematic fashion key public-policy questions such as: (1) what kinds of land-use controls have had what consequences, and for whom; (2) what are the consequences of alternative administrative structures for enforcing land-use controls; (3) what have been the impacts (trade-offs) of the existing sources of funding for land-use planning; (4) for what reasons have the private and public sectors accepted or rejected proposed land-use controls; (5) what have been the consequences (positive and negative) of encouraging self-regulation by rural residential home developers?

A multi-phased study of the rural residential development "industry" is needed to comprehensively assess the nature of its producers, developers, financiers, and consumers and subsequently, to understand their impact upon society. As

an essential part of the analysis, research is needed to examine the impact of promotional activities, sales methods and techniques associated with rural residential developments, as well as an in-depth analysis of the factors which affect delivery of "promised" community services or other amenities. The analysis could examine the "real" as well as the "imagined" benefits of rural residential living and particularly of second-home ownership. Time series, cross-sectional data would be desirable for a complete examination of the influence of these factors under varying types of governmental regulation.

Another research phase should consider how these new developments are governed; have they become extensions of existing local and state governments, or do they form or intend to form new political entities? This study would also include an examination of the relationship between the new developments (and the new governments) and existing political entities.

As an integral part of this evaluation, analysis should be undertaken of the governmental processes by which such plans are adopted and then enforced during development. The study should indicate where the regulatory responsibility lies (whether at the local, regional, or state level) and to what extent there has been direct citizen input into the planning process. (Obviously, such detail should indicate whether or not the rights of individual landowners are going usurped by political entities and/or citizen groups.)

The total study should help arrive at an understanding of the power (political) structure and help assess the most effective ways other developments acted to achieve desirable

Figure II
PROCESS OF ASSESSING POSITIVE AND NEGATIVE IMPACTS OF POLICY DECISIONS

GIVEN (Policy decisions which have al- ready been made)	ECONOMIC				BIO-PHYSICAL				SOCIO-POLITICAL				OTHER			
	Public/ Gov't		Private		Public/ Gov't		Private		Public/ Gov't		Private		Public/ Gov't		Private	
	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Legislative																
Administrative																
Site Selection																
Etc.																

legislation and policies. It is particularly critical that we understand more clearly how to plan for future legislation and policy implementation and at the same time, not infringe inordinately upon the rights of individuals in the use of their land.

The final phase of this recommended research would be to examine the impacts of specific regulatory policies. The following charts are submitted as a means of classifying the political impacts of Federal, State, local and self-regulatory activities. These charts provide a framework for the organization of activities and actions in terms of their political impact upon rural residential development. By assembling the information to complete these charts, an evaluation could be made of previously successful public policies, and possibly help define some alternative public policy and implementation techniques applicable to future rural residential developments.

[illegible]

Exhibit C

CLASSIFICATION OF FEEDBACK, REGULATORY ACTION			
CHARACTERISTICS	DEPARTMENT	ADMINISTRATIVE COMMENT	IMPACT

Exhibit A

[illegible]

Exhibit D

[illegible]

Exhibit B

[illegible]

Exhibit E

Finally, the following recommendations are suggested as a means of facilitating implementation of existing and future research findings:

1) Greater use of existing research publications (for example, Federal Register, Housing and Development Reports, Compendium of State Draft Legislation, Topical Law Report, Urban Affairs Reporter).

2) More coordination, sharing of information, and cooperation among states and between states and the private sector. Existing institutional arrangements which might be utilized to enhance cooperative sharing of information include but are not limited to: Council of State Governments, Commission of Uniform State Laws, Office of Interstate Land Sales Regulation, Federation of Rocky Mountain States, and private development associations.

3) A review was made of existing compilations to identify specific relevant items of Federal, State, and local government legislation. Suffice it to say that the amount of information compiled and available is minimal. Development of a model for effective land-use regulation is badly needed and one is presently in preparation.³⁷ Such a model might take the form of a "uniform" or model legislative package, having options or alternatives based on regional differences.

In summary, what is lacking at present is a procedural method for drawing together available knowledge and data and a system of analysis that can be interpreted by the user and decision maker. And finally, a uniform method for sound land-use control is long overdue.

³⁷American Law Institute, A Model Land Development Code, Tentative Drafts, 2, 3, and 4 (1970, 1971, 1972) Philadelphia: ALI.

APPENDICES--I, II, AND III

Appendix I

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APPENDIX II

ANNOTATED BIBLIOGRAPHY

Allen, James B., *The Company Town in the American West*. Norman, Oklahoma: The University of Oklahoma Press, 1966.

The material included in this research consists of case studies. The first five chapters relate to early towns and specific industries. Chapters reviewed here relate to social and economic aspects of the company town.

I. Community Planning and Housing: Modern company towns are laid out in a planned, orderly fashion, determined largely by terrain. By the 1920's most coal mining communities had wide streets and ample lots. Considering the location problems, towns such as Morenci Ag., where terracing is required (the school playground is on top of the school) are exceptionally well planned. Problems exist when land on which town is built may be needed for mining!

A. Benefits of company towns: Employees can get to work quickly and easily. Squatter shacks and slums could be removed and controlled by the company. In general, today's towns boast of living quarters comparable in every way to those available in a small town. Low rents, medical costs, etc., were also among the benefits.

B. Disadvantages: Location close to mine and mills might be troubled by air pollution--smoke, grass killed, dust, etc. Early housing was often uniform and dull. Bare necessities were often the only provision. Foreman and manager generally fared better. Non-white and foreigners often were relegated to the lowest housing levels. ex.: No running water. Maintenance dependent on company policy but also on employee attitudes and habits. Monopolistic control over shopping, etc., would be disadvantage for workers.

C. Amenities: Early towns had few parks, trees, paved streets. Many current towns, however, do not follow such patterns. Isolation often went along with closeness to natural recreational opportunity--eg. hunting and fishing.

II. Human Welfare: Companies were usually in business of providing the usual government services: recreation, health, welfare, religion, education.

When given a choice, most natural born white Americans chose not to live in company towns.

The company often served as a substitute for city government--and had strong control over local (county and school) political affairs.

Though community services were relatively inexpensive (hospital, fire protection, etc.) they were often inadequate as well: There was a lack of standard procedures for provision of community services.

Building of company towns took a substantial investment; data on this is difficult to obtain. Company towns could absorb at least 5% of the original cost of developing a mining property, town maintenance is considered to be provided at an economic loss by many managers.

In 1952 it took 1/4 - 1/3 of a worker in the services field to support one worker in the company's primary business. Service workers at that time earned only 59% of what the workers for that primary business obtained.

New Company Towns: ie., San Manuel Ag.: Model community--homes sold to workers, development firms plan and build; businesses are leased or sold.

Dispersal of many company towns has been carried out through sale to an intermediate Real Estate Co.: (John W. Galbreath and Co.) and then parceled out to previous residents and others through this mechanism.

American Law Institute, A Model Land Development Code, Tentative Drafts 2, 3, and 4, (1970, 1971, 1972) Philadelphia: ALI.

From Tentative Draft 2, Introductory Memorandum: in comparing recent criticisms of existing planning law, remarkable consistency is found between the points made, and they may be summarized as follows:

"1) the attempt to guide land development by prohibitions and restrictions, without using the power of public acquisition and disposition of land and the power of public spending to secure desired development, is likely to be an ineffective method of ordering land development.

2) The unrestricted grant of power to the smallest unit of local government has produced a distortion in metropolitan growth and almost impotence in attack on regional problems such as pollution, inadequate supply of decent housing, proper management of the environment, transportation and the like.

3) The unrestricted grant of power to local governments has produced in many cases incompetent planning and in many others an administrative process which runs counter to many concepts of fairness and orderly procedure.

4) The idea of a "static master plan" that is a map representing optimum civic design in its ultimate form has not only failed to guide land development because no legal significance has been attached to it...but the idea itself is faulty, because the forces of urban growth and decay are too dynamic to be ordered in such a rigid fashion.

5) Ordinances enacted under existing laws by a host of small but growing urban communities at the periphery of a large metropolitan complex have been unable to deal with large-scale development of viable new communities. "Industrial parks," "residential subdivisions," "regional shopping areas," may result from existing zoning districts but the relation of industry to housing of the work force and the relation of each to a whole complex of urban services such as schools, hospitals, daycare centers, neighborhood shopping centers, and the like are often ignored, in part, because the unit of government regulating development is too small to plan comprehensively for these services."

Professional planning literature poses the following questions:

1. Is there a machinery or process for governmental action which offers more promise of ensuring forethought than do other possible governmental procedures?

2. Are there some governmental decisions concerning land development so fraught with undesirable consequences if made irrationally, parochially, or prejudicially that the power to make such decisions should be denied to local governments who do not have competent professional planning staffs or denied to certain levels of government altogether?

3. Is there an optimum level of government for allocation of responsibility for planning?

4. Does machinery devised to encourage forethought become so expensive and cumbersome that eventual decision making is too late or not at all?

Bowers, J., S. J. Brasher, V. Gow, and N. P. Jannakos, *New Communities in the Rocky Mountain West* (preliminary draft), Federation of Rocky Mountain States, Inc. Denver, Colorado, 1970.

New community potential in the West:

1. Only Denver, Wasatch Front, and Albuquerque will have enough population growth to support new cities of a multi-purpose, integrated nature.
2. A number of regional centers and smaller cities may have potential for planned expansion of existing peripheral settlements.
3. Economic considerations indicate that there is a potential for smaller, single-purpose self-sustaining new communities in areas of natural resources and tourism. Such a settlement should be planned with its short-term or seasonal nature in mind. Efforts should be made by both federal and state to develop spin-off industries and services to offset resulting economic instability.

Identification of potentials for new communities is difficult and certain indicators are appropriate under varying conditions. Some such indicators are:

1. population and projected growth
2. economic and social potential
3. access: type of transportation provided and settlement patterns are closely related
4. availability of land (Rocky Mountain cities are less dense than other large cities)
5. capability for comprehensive planning (Rocky Mountain states lag behind others here)

Discussion of the designation of growth centers throughout a region as a tool for planning, to stimulate a real development, and to aid rational allocation of state and federal funds.

Following the above discussion, several case studies of new communities are presented. These cases imply the following research needs: If it is determined to be in the public interest to build new communities by expanding existing small communities, what programs are needed by state and federal government to assist the existing communities in realizing this expansion in an orderly way? What alternatives are possible and what are the consequences of a true "new community" and the expansion of an existing community? What are the trade-offs involved and how does transportation and distance effect these trade-offs?

Lessons learned from case studies:

1. New community approaches offer economies of scale and can result in better design.
2. There is need for public policy that will encourage this approach, but offer balance that will harness and direct land speculation and development associated with it.
3. Tools are needed for analysis of the impact of new communities on regional and state levels. An information and analysis system needs to be developed.
4. Governmental inefficiency in response to development plans is costly and ways to streamline procedures are needed, while adequate checks are maintained to protect the environment. One way to handle this would be with the concept of single office for coordinating help to large developers, and a single "site-Certificate" which would combine all required examinations: sewers, schools, roads, etc., which is issued on the basis of pre-determined performance criteria. Research to aid the setting of such criteria would be helpful.

New Communities in the Rocky Mountain States, Ch. III.

Reports on five studies evaluating community management and investment systems. (References are included in Appendix I)

These reports deal with: the present state-of-affairs with respect to urbanization of U. S. society, social, economic, governmental problems related to said state-of-affairs, government policy needed on all levels to generate solutions to these problems, present types of public or private management and investment systems participating in new community development programs, and recommendations for improvement of systems for implementation of new needed policies.

Summary of apparent consensus among these studies: need for integrated government effort to develop a growth and population redistribution policy, along with policy components of natural resource development, human resource development, and environmental protections, there must be a new communities development policy component which will be addressed to creating integrated public and private programs which will result in human habitats responsive to the physical, social and inspirational needs of all their residents; establishment of public or private or combined new community development management systems; (p. III-4). For economic feasibility, there is need for long-term, low-interest, government-guaranteed loans for the comprehensive planning of public community services, natural resource recovery, and local government systems.

Research needs:

1. What would be the relationship between a state-chartered new community development management system and the present systems now operating in core city renewal and metropolitan organization?

2. How can U.S. science and technology help most the needs and challenges of such new community development programs?
3. Evaluation of new communities:
 - a. What are the criteria for judging if a current new community is successful?
 - b. What are the criteria for selecting from the successful new communities those which would be appropriate models for new communities in the Rocky Mountain states?
4. Research, development, and application of a strategic planning framework for identification and selection of new community locations within multi-state regions according to specified criteria (some possible lists of criteria, p. III-6).

Chapter V, Rocky Mountain state actions needed to facilitate new communities, contains specific recommendations directly related to existing regulations in the various states, pointing that experimental development could well be located in the Region, due to the large federal land holdings available.

Bureau of Outdoor Recreation, Water-Oriented Outdoor Recreation in the Lake Huron Basin, Lake Central Region, Ann Arbor, Michigan, October, 1969.

There are about 44,000 private seasonal homes in the Lake Huron Basin, Michigan. Most homes are concentrated in areas adjacent or near water. Much lakeshore frontage is used this way, substantially limiting access utilization by the general public.

Ski resort-oriented vacation home sites are becoming available away from existing lakes and rivers. Cluster developments, and reservoir and pond construction are also used by developers to meet demand for summer home environments in the face of existing intensive development and conservation trends relating to current shorelines.

Seasonal home building is rapid and often accompanied by complete bulldozing of lots, crowding, and look-alike mass production. Zoning ordinances are sometimes ignored by contractors and realtors. Direct acquisition is the only successful land use control system that has been found.

Many private and semi-private lakes are in a condition of having too many closely-packed seasonal homes with poor sanitary systems, cluttering shorelines and polluting lakes. Here a central sewage system might bring benefits and and enjoyment enough to justify its costs. For lakes not yet in this condition, strictly enforced zoning regulations are needed.

The Subdivision Control Act of 1967 may aid in improving environmental quality through requiring percolation and boring tests prior to installation of septic systems, and the Michigan Water Resources Commission is empowered to reject a preliminary subdivision plat.

A shorelands act in 1962 in Wisconsin provides for county zoning for unincorporated shorelands of navigable waters. (Including those navigable by skiff of the shallowest draft.) Counties must adopt an acceptable ordinance or one shall be adopted for them. Regulations include soil suitability for septic systems, tree cutting limitations, setback of structures from waters edge, minimum lot sizes, erosion control provisions, use of subdivision controls such as cluster development. Michigan could benefit from such an act as well.

Property owners on lakeshores should be encouraged to organize action associations for the purpose of controlling water pollution and other environmental problems. Publicity of such activities should be afforded these groups.

Cameron, Juan, "Growth is Fighting Word in Colorado's Mountain Wonderland," *Fortune*, October, 1973.

The real issue in Colorado is how growth can be contained and controlled to maintain a hard-won prosperity without destroying the natural grandeur of one of the nation's most beautiful states. Colorado still has a chance to meet its environmental challenge.

More and more, land use patterns are seen as the root cause of environmental deterioration, with air and water pollution seen as symptoms.

Recreation-oriented towns and an influx of new residents have encouraged land developers to open subdivisions up and down the eastern slopes of the Rockies. Altogether, such subdivisions could house 3 million new inhabitants. Water is piped through the mountains from the West slopes and Western Coloradans are now resenting this diversion of water they have used in the past for livestock, etc., and desire to use for oil-shale development.

State regulations: developers must inform state about plans, restrictions on water well drilling (effectively controlling building in arid areas), state land use legislation has been proposed, but not accepted as yet.

Boulder's regulations: financing foothill open space through a 1 cent sales tax, restriction on areas to which the city will provide water, increase in charge for water connection from \$600 to \$950 a dwelling, 55 ft. height limit on buildings, moratorium on incoming employers, public or private, until planning is completed.

The U.S. Forest Service has warned that the rural subdivisions built in pockets of privately-owned land in the national forests are a serious fire-hazard. A blaze in one of these communities could easily touch off a catastrophic forest fire.

Aspen regulations: building-permit procedures require a rigid adherence to standards, such as the amount of land provided per dwelling unit, and Aspen zoning now applies throughout Pitkin Co. Other aims: increases in utility fees and development charges. (One new development proposal would cost the county taxpayers \$60,000 more the first year after completion than the new development would pay in taxes.)

Campbell, Charles E., *The Economic Impact of Rural Subdividing in the Arid Southwest: Development of destruction*. A paper presented for the Symposium on the Physical and Cultural Barriers to Urbanization in the Arid Lands, the University of Lethbridge, Lethbridge, Alberta, Canada, August 3-8, 1972.

Massive fragmentation of rural land ownership in the arid southwestern U. S. may represent a formidable cultural barrier to future constructive urbanization. Collective consideration of developments indicates the physical capabilities of support for proposed future land uses may well be lacking. Almost the only amenity present is a dry and warm climate.

Extensive occupation of this type of land is unlikely. In most cases the developer has not considered the availability of basic services, vital utilities, employment opportunities, or a functional economic base needed to maintain a substantial permanent population.

The author hypothesizes that the least desirable land will first be subdivided, prior to the more productive land. Therefore, the economic impact of subdivision will increase in intensity as the supply of non-subdivided land decreases.

Future problems discussed include:

1. Acquisition of land for substantial new development when needed will be costly and difficult. This problem is accentuated by the "artificial" increase in market value of subdivided land, and the problem of tracing small parcels of land belonging to numerous absentee owners. Even if large parcels were available from the government, the small inactive subdivisions would remain "non-productive."

2. If the land owners in large numbers decided to develop their property, cluster housing, and other special innovations would be precluded by prior developmental patterns. Provision of services of urban type around many unused plots would be costly for the home owner and the local governments.

3. Wide subdivision would disrupt the rural economy, and establishment of a method to monitor this rate of productivity is suggested.

If these lands remain undeveloped, and are difficult to develop, they may serve as a conservation reservoir providing a real but intangible service to society.

Clapp, James A., *New towns and urban policy: Planning metropolitan growth*, New York: Dunellen, 1970. (has a sizeable bibliography)

By criteria stated in this book most company or recreational towns would not be considered "new towns" as the industrial base is not broad enough. Some considerations here, however, apply to the theme under study.

A distinction made between new towns and suburbs is one of the provision of balanced land use: inclusion of multi-unit residences, shopping areas, parks, churches, offices as well as single-unit family homes.

Single ownership of new town land permits a direct linkage between planning and development.

The problem of transportation in urban areas is one of the best cases for the new town approach to urban growth. Excessive expenditure for highways is a result of suburban sprawl, as development about nodal centers would facilitate effective mass transit, and if such centers were somewhat self-sufficient, need for some travel could be alleviated.

Chapter 6 contains an analysis of some of the operational considerations of alternative new town programs. The greater the level of governmental acceptability during the planning stages of the program. With private programs the problem becomes the utility of the program for the public guidance of growth: the initiative for guidance would be weaker local governmental units. Also locations of towns are thus the private developer's decision. Public development corporations might be better able to influence location from a point of view which would take into account and influence location of other publicly-owned assets such as highways, universities, etc.

One major point taken in favor of a new towns approach is that experimentation and innovation is allowed. However, in reality, with private financing it is often true that innovation is feared and avoided.

Another question of interest, is, when a self-contained community is envisioned, all of the seamy side of life is left out, and those who wish to partake of it must go to the big city. Therefore, are the new communities really self-sufficient without an unplanned honky-tonk?

Congressional Research Service. *Property Taxation: Effects on Land Use and Local Government Revenues*, prepared for the Subcommittee on Intergovernmental Relations, U.S. Government Printing Office: Washington, D.C., February 24, 1971.

The consequences of scattered rural developments are:

an attempt by local transit to provide transportation, but there is a lack of enough regular customers to cover the service costs

the suburbanites depend on their cars to travel longer distances to work, shop, or be entertained. Urban roads become more jammed and now wider roads must be constructed

there are increased costs to lengthen water lines or to build separate systems. The smaller the population served by a water system, the higher their rates

sewage treatment is most economical on a large-scale basis. Septic tanks are often not satisfactory, and great expense is incurred by the property owners when they must change to a centralized system

Denney, Evan, Carlson, Steven A. and Crowley, John M., *Land Use Capability Study for the Diehl Development Corporation*, S. E. Helena Project, 1973.

This study constitutes a biophysical approach to the planning and design of 10,665 acres Southeast of Helena by the Diehl Corp. The area is classified according to several types of land and their capabilities for use. Geologic hazards were considered, wildlife interpretations, biophysical, climate, drainage, pollution, and cultural-historical studies.

Specific analyses and recommendations regarding air pollution (control of open burning, dust, and output of heating units), water pollution (septic tank effluent and acid wastes from mines), and noise pollution (minimal traffic and trains, airplanes, motorized vehicles on the development site). Motorcycles and snowmobiles constitute the worst offenses, causing a problem for wildlife and humans in a tranquil environment, and causing damage to vegetation.

A desire to preserve the history of the site is indicated. Many of the historical features of the site may be preserved and become an integral part of a trail system with appropriate signs of an explanatory nature. In the case of mines, caution must be exercised to provide for public safety.

Dumper, Thomas A., "The Impact of Urbanization on Watershed Development," *Journal of Soil and Water Conservation*, Vol. 21, Jan. - Feb. 1966, pg. 24-26.

Growth of communities in agricultural areas requires better schools and more services; hence an expanded tax base which results in more residential development.

Watershed Developments

Intensive residential and commercial and industrial developments create the greatest runoffs.

Paved areas allow a lot of runoff, but little erosion.

High runoff rates during construction and landscaping may create maximum erosion.

Conditions caused by this runoff: flooding, stages of inundation, decrease in protection provided by a reservoir, increased possibility of structure failure.

Increased erosion with runoff problems may cause a reduction of planned flood storage due to sediment accumulation; loss or impairment of recreation facilities due to excessive sedimentation or turbidity from erosion.

Construction accompanying a residential development, because of a decline of stable tree and grass cover will result in a loss of nearly 3,500 tons of soil per square mile by 1985.

The Environment: 1972 EPA Summer Fellows Project
(Summary): produced for Environmental Protection Agency, Office of Research and Monitoring.

Five separate studies on: (1) quality of life; (2) pollution and municipality; (3) consumption differentials and the environment; (4) outdoor recreation and the environment; and (5) environmental management.

(4) Outdoor Recreation and the Environment

Bruno Kimmelman (head) and Keith Bildstein, Paul Beyak, William Horton and Mary Sarina.

Increases in population and leisure placing demand on existing facilities and for new facilities.

Outdoor Recreation on Private land—from picnicing to skie resorts; ecological balance and fiscal cost-revenue.

Second Homes:

68% on seasonal basis

28% intermittantly throughout the year

6% for retirement

Revenue of second home impacts in coastal areas:

demand for beaches - abuse and impacts

in urban areas;

Future Recreation Trends

Need for expansion of facilities or limited participation.

Fellmeth, Robert C., *Politics of Land*, New York: Grossman, 1973. (Ch. 8 New Development)

This chapter cites several case-histories in California:

(1) The development of the Antelope Valley north L.A. and its subsequent acquisition of the site approval for a new intercontinental airport, without adequate consideration of alternative sites. Opportunistic zoning had much influence.

(2) Several cases of sale of unstable shore land, and complete unconcern for building and sale of land on known geologic faults. It is estimated that a major earthquake during working hours could cause 1 million deaths in the L.A. area.

(3) Foster city, east of San Mateo, where the developer formed his own special improvement district and financed dredging, drainage, and sewage improvements through tax-exempt public bonds, then selling the land for as much as \$18,000 per acre more than he paid for it due to its improved status. As property is obtained privately, the responsibility of paying the bonds off becomes the property-owner's. Specific problems caused by this development included: overburdening the land with debt, limiting further improvement; construction of faulty improvements; developer may divert funds; improvements created before need, and deteriorate before use.

(4) California City, a "perfect example of development fraud." Acquired at \$109/acre, this 100,000 acres, 90,000 plot development sells without utilities, water or paved roads at \$9,000/plot. 32,000 parcels have been sold. After 12 years it has a population of 896, which is almost entirely dependent on the developer for employment or income. The fraud consists in advertising the existence of "abundant water" when, in fact, there is not such "abundance." Lot purchasers are encouraged to make an "investment" when, in reality, resale of lots has resulted in losses.

Two basic laws govern Subdivision in California:

(1) Subdivided Lands Act: Basically a disclosure law, puts no restrictions on developer, except that he must give special information to be included in a public report which is to be made available to the prospective buyers. No penalties are applied to those who fail to follow the act, unless they have first ignored a restraining order. Also this law is not vigorously enforced.

(2) Subdivision Map Act: places responsibility for subdivision regulation with local units of government, requiring local units to have supplemental local subdivision ordinances. The purpose is to coordinate subdivisions with local plans, and insure improvement of public areas without excessive taxation. Local ordinances are usually so liberal and so many exceptions granted, that his act has served to be an abdication of the state government.

Enforcement of these laws are the business of the Department of Real Estate, whose Commissioner must have had five years of experience in the real estate field. He must relinquish his license temporarily, but the seven advisory commissioners need not. This entrenched special interest on the Commission has served to maintain developmental abuse.

Recommendations for improving the situation include:

(1) demonstration of the need for the final product of a land development project.

(2) assessment of fees for residential or commercial conversion of land with an external "social value" (coast, wild, agriculture) to encourage development elsewhere first.

(3) ban on development until proper ground can be guaranteed through geologic research

(4) abolition of "holder in due course doctrine" enabling developers to hide behind banks and commit fraud without remedy

(5) abolition of independent special improvement districts

(6) stricter performance bonds required of developers for completion of projects

(7) vigorous prosecution of fraud and strict fines and imprisonment

"For second-home owners: a stiff new tax rule; buy a beach cottage as a tax haven", U.S. News, 73:63-4, July 24, 1972.

New tax regulations published July 12, 1972, retroactive to Jan. 1, 1970, consider beach cottages or vacation homes which are rented only part of the year and used for family recreation by the owner as well to be primarily "not-for-profit" and therefore such purchases may not be written off as profitable enterprises or used as a "tax shelter"

Hill, Alan T., "Residential-Recreation Development Prevents Soil Erosion," *Civil Engineering*, Vol. 41, December 1971, pg. 60-3.

Cites a road with deep crevasses to demonstrate what happens to steep roads with no pavement or slope protection in areas of heavy precipitation.

The development of a subdivision on rough broken soil, extremely subject to erosion.
(Wild Horse Mesa)

They sold 40-acre parcels, on which nothing could be built and no improvements made--no changes of the natural environment.

Purchasers of lots entitled to stock in property-owner association. They controlled 365-acre community center, with all facilities and single family housing.

Forty-acre parcels of land remained open for fishing, hiking, etc.

Innovation and New Communities, The Princeton University Conference, co-sponsored by National Urban Coalition. Robert L. Geddes, Chairman; Sonathan B. Howes, and Elizabeth B. Kassler, November 1970.

A variety of opinions on the development of new communities.

Local development and control versus state and national.

Interactions between technology and new communities. The major conclusion was that there is a need for new experimental cities; testing of theoretical ideals and to monitor impacts of all natures.

Issacson, Larry, *Park and Recreational Facilities: Their Consideration as an Environmental Factor Influencing the Location of a Highway*, U.S. Government Printing Office; Washington, DC 1971.

pg. 4:

A six-lane highway bordering a natural or pastoral area would cause excessive sight and noise distraction for 400 ft. plus if the ground is level.

pg. 6:

If the ground is mounded and tree belts screen the highway, excessive sight and noise distraction will be present for 200-250 ft. in natural and pastoral areas.

pg. 19-21:

Highways in class I and II recreation areas should be designed with buffer zones and respect the natural environment.

Class III areas should only have limited access roads and trails.

Class IV - only roads on the perimeter

Class V (primitive) - the sight, sound or smell of a highway is a direct violation of the criteria which establish primitive area.

Class VI - highways through and adjacent to cultural and historical areas are established according to specific criteria of the area.

Johnson, Morris E., *Utah's Subdivision Problem*, Bureau of Community Development, University of Utah, Salt Lake City, Utah; August, 1973.

This study found a total lack of uniformity in local government procedures involving approval, building permit issuance, and implementation of related ordinances concerning subdivisions located in unincorporated areas.

Subdivisions in nine counties were studied. The following facts were uncovered: 130 subdivisions recorded in the 1962-72 decade were in unincorporated areas, divided into 26,766 building lots averaging about an acre in size. The counties studies contained approx. 28,316 families in 1970. Obviously, these subdivisions were made far in advance of the demand for them. 12% of the roads in the subdivisions were paved, 59% gravel, remainder, dirt. 1/3 had no available water source. 95% no sewer system, 40% no electric power. 15% were tax-delinquent. 63 of these subdivisions classify as second-home, recreation types. 15 might be considered standard urban developments, and 12 completely lacked amenities, and were thus classed as non-functional.

In many cases, responsibility for road upkeep was undetermined, and little attention has been given to the relationship of one subdivision to another or the need for land provisions for such urban services as schools, churches, playgrounds.

Prime agricultural land is often taken out of production, and as the supply is greater than the demand, it is lying idle. It is recommended that such land be available for agriculture until such time as it is required for housing.

Once demands are made for urban services at some to the more remote subdivision areas, the costs are likely to be much more than tax revenue generated by these subdivisions.

The general pattern is that lots sold remain unused, and development stops with one or two lots. Case history: Hillside location best served by inconspicuous cluster housing and open space: developed in an intermediate fashion - low-density large private lots. Still open to degradation if owners fence lots try to keep livestock, etc.

Kovach, Bill. "More Americans Getting that Home Away From Home." *New York Times*, April 6, 1971. pg. 23.

The market for second homes:

1. A Philadelphia Bank reported than one out of every twenty mortgage inquiries were for second homes
2. By 1975 there will be a market for 200,000 vacation homes every year
3. Vermont expects decreases in second home construction, as more are being converted to primary homes

The State of Montana, *Proposed Model Subdivision Regulations*, October, 1973, (mimeo)

I. Procedures

A. Plat Review and approval, Guarantee of Public Improvements

1. All required improvements must be installed, or subdivider must provide agreement guaranteeing their construction. Acceptable security agreement is required, can be S.I.D., R.I.D., county water or sewer districts, performance or property bonds, Private or public escrow agreements, loan commitments, assignments of receivables, liens on property, deposit of certified funds, etc.
2. Plans for improvement must be submitted for approval prior to their construction.
3. Governing body MAY provide for inspection of such improvements prior to plat approval or release from improvements agreement.
4. Collateral may be released to subdivider as portions of the improvements are completed, inspected, and approved. Deficiencies shall be corrected before all collateral is released, and if it is determined that parts of the agreement will not be complied with, collateral is to be used to construct the improvements as specified.

III. Design and improvement standards

A. Land Subdivisions

1. General Standards

- b. Natural terrain, drainage, topsoil, trees, and vegetation to be preserved where possible

2. Unsuitable lands shall not be subdivided unless problem is corrected (flood hazard, landslide, slope, high water table, etc.)
3. Floodway provisions

9. Water Supply - minimum state standards, subdivider must connect to main if available and construct system within subdivision. Adequate for fire protection.
10. Sewage Disposal - minimum state standards, central system may be required for large subdivision
12. Utilities - specifications
14. Parks and Open Space - A proportion of platted area must be dedicated to parks in plats with lots more than 10 acres, or cash donation given when dedication to parks is not possible or undesirable.

Moore, Arthur L., "Reservoir Recreation and Local Economic Growth," *Economic Studies of Outdoor Recreation*, O.R.R.R.C. Study Report 24, 1962, U.S.P.P.O.: Washington, D.C.

Concerns studies of reservoirs created in the '40's and '50's in Oklahoma and Arkansas. Second homes were considered along with many permanent homes which were basically for retirement or semiretirement. Even second homes were of a quality to be permanently usable in most cases.

Army Corps of Engineers land purchase policy in creation of early reservoirs (Texoma, Norfork) contributed to quality homesite development. In later projects this policy was discontinued (Table Rock) and rapid development is ensuing due to private management. However, there are no checks on the quality of this development.

Zoning is one answer to the problem, but not very many local governments appear to be interested. Another answer would be control of land use by means of easements.

The longrun demand for recreational facilities may conflict with the homesite usage of lakeshores, therefore, adequate land should be set aside. However, properly safeguarded homesite development should be regarded as an integral part of water resource development.

Revenues from recreational development appear to be adequate to cover services required, but they tend to go to the state in the form of sales taxes, and not always get back to the county in which recreational activity is necessitating increased services. Homesite development tends to increase property taxes, which do tend to go back to the counties. Some problems are seen in increasing assessed valuations when property values increase due to surrounding development brought on by the reservoir.

Most frequent complaint: poor county roads, inadequately built and kept up. County officials tend not to see connections between good roads and increased revenues, and data on this problem does not exist. Adequate roads might be included in cost of reservoir, with understanding that county will be responsible for their maintenance. Current Corps policy seeks to maximize recreation responsibilities of State and local governments. This has not worked to provide adequate connecting roads.

Gain in revenue to school districts is not matched by a proportionate increase in school children, and reservoir counties should see an increase in quality of education.

Myers, C.W. Jick, "The Arizona trade-off model" *Arizona Business*, March, 1973, Bureau of Business and Economic Research, College of Business Administration, Arizona State University.

Conflicts between economic growth and environmental quality necessitate compromise, but adequate information is not available to resolve such conflicts in a manner that will maximize the total well-being of the population.

The Arizona Trade-Off Model is designed to furnish public officials with information useful in analysis of trade-offs involved in making policy decisions, especially those related to conflicts between environmental quality and economic growth. Economic impacts are described in terms of projected employment changes. Consequences of policies are also assessed in terms of their projected environmental impact. No attempt is made at arriving at an optimum solution of trade-offs. Information is now available to assist public officials in charting the future of the State of Arizona, that had been heretofore unavailable, concerning the efficacy of alternative policies in obtaining desired results. (This is not seen as applicable to land development by the reviewer, as short-run employment is created by land development, but without another source of jobs, a "land boom" type of development appears to have negative effects on the environment without compensating for it by a positive projected employment gain.)

Physical, Ecological, Economic and sociological Effects of Residence Patterns of Recreationists on Four Maine Lakes

Mr. Joseph M. Wunderle, Jr.
c/o Dr. Ronald B. Davis
Department of Botany and Geology
University of Maine
Orono, Maine 04473

The above study is currently being worked on. It is not known with state the study is in, if any preliminary findings have been reported as yet, or if any reports are presently being published.

"The quiet boom in the vacation home market" R.L. Ragatz, G.M. Gelb, *California Management Review*, 12:57-64 Spring, 1970.

Unmet demand for vacation housing exists. 5% U.S. households own second homes; one study in Houston found 39% of sample (income over \$3,000/yr.) gave serious thought to second homes. 10-15% of new housing starts are second homes.

Home (second) ownership rises with income, several studies cited, though it rises more rapidly than income. Adequate income and leisure are necessary to the market.

Vacation home communities: Average acreage (1969) 2,000/community, of which 1/4 of the land is devoted to recreation - golf courses, lakes, etc. Financing is the largest single limitation in the growth of the market. Now somewhat available under 1968 Housing Act.

"Public and private benefits" MENTIONED, not itemized, cost: less of population is cities during summer months and on weekends.

Boise-Cascade, as of mid-1969, had 23 vacation communities under development. (See Abstract 12)

Rahenkamp, J. "Valley reserves for Megalopolis" *Landscape Architecture*, 58 (1):22-24, October, 1967.

Layout of development according to land constraint: not vacation homes, but applicable to them.

Valley stream formed natural routes through development. Open fields not suitable for concentrations of people; nor was stream valley and valley wall. Prime area chosen was woodland strip between valley wall and open fields. "Man can mesh quietly with the wooded areas without destroying them while living in groups around open spaces - a pattern which encourages social interaction and participation."

Spear, Michael D., "Economic modeling for new town evaluation" in Weiss, Kaiser and Burby (eds.) *New Community Development*, Vol. I, New Towns Research Seminar, Center for Urban and Regional Studies, University of North Carolina, Chapel Hill: 1971.

Spear is vice president of Rouse Co., which built Columbia, Md.

- I. The development process
 - A. Land acquisition - hazardous, surprise and
 - B. Preliminary land management (prior to development)

- C. Programming and planning - judgement about market support important here, affects pace and price
- D. Legal and political approval - time consuming and critical
- E. Securing capital
- F. Development of infrastructure - includes schools, parks, educational and cultural facilities, roads, sewer and water
- G. Marketing - producing housing, industry, office spaces, environment, and community, then selling or leasing it
- H. Long-term maintenance - through homeowner's association or local governments

The development process is an enormous management task: for towns such as Columbia, management alone costs two million dollars yearly.

The remainder of the seminar is devoted to a description of economic modeling of the consequences of development. The model must address itself to: different kinds of monetary returns, measures used to evaluate development opportunity, critical variables such as physical capacity of the land, development costs, market support, and financing arrangements. Also the model must be flexible in that it can assume varying points of view, that of developer, original landowner, builders, speculator, builder-owner of income property (rentals), lenders, and finally, local government.

Economic models have value for: (1) evaluation of development plans, testing assumptions, (2) presentation to: investors, local government, and community at large, (3) management of development process, and, more specifically, (4) determination of suitable price and acquisition strategy for the land, (5) testing alternative mixes of uses, alternative paces, and alternative financing variables. Finally, they can be used for testing alternatives in production costs and product prices, and assessing the effects of economic changes or demographic changes in the nation at large.

"A troubled industry gathers for American Land Division Association land conference, but concern over today's problems offset by long-term optimism," *Recreation Land and Leisure Housing Report*, 4:19, pp. 1-4, October 31, 1973, Los Altos, California.

Mortgage money squeeze has inhibited development financing. Lenders are scrutinizing developer operating practices. Consumer market has slowed down because of inflation, "the Nixon mess," and the energy crisis. Also OILSR's new regulations effective Dec. 1, and the gathering momentum of Land use regulation are having the effect of slowing down developers.

Long-term attitudes are optimistic, as reputable developers see regulation as driving out shoddy competitors, and are presently reassessing the product in the attempt to offer more variety, and to pinpoint market wants, therefore tailoring to buyers instead of continuing the philosophy of fraction-of-an-acre lots wrapped in bigger and better amenity packages.

Some areas considered are: tennis oriented projects, campground projects (customers want cheaper lots and fewer amenities) time-share condominiums (?) "farm" parcels (1-5 acres)

U.S. Dept. of Agriculture, Economic Research Service, **Economic impact of second-home communities: A case study of Lake Latonka, Pa.**, R.N. Brown, Jr., November, 1970. (ERS-452) Washington, D.C.

Time frame: 1964-1970.

Transforming 1,275 acres of cropland and pastureland into second-home community brought added income to local business, rise in tax revenue, and little or no change in demand for government service.

Financing produces interest income, but not locally to a large extent.

Maintenance expenditures are expected to create much local income.

Rise in tax revenues relating to an increase of tax base of \$1.8 million should more than cover cost of additional services demanded of local taxing districts.

Demand for school facilities was not appreciably increased by the community as long as it remained primarily second-home.

Little economic activity was displaced; other agricultural land was available to make up for production lost from development.

U.S.D.A. Forest Service Environmental Statement: Kirkwood Winter Sports Development, Eldorado National Forest, 1973.

Major impacts on soil, water and esthetics -- all can be minimized by planning and careful construction.

Increased usage of neighboring forest lands, including a wilderness area - may be a need for control.

Shallow soils erode; deeper soils better for roads, ski runs, etc.

Water pollution from: stream bank erosion, sedimentation from eroding, exposed soils, fertilization from revegetation, enadequate sewage; and polluting runoffs from impervious surfaces such as parking lots.

Air quality changed by increased vehicular traffic, fireplaces.

Noise from cars, avalanche monitoring affects animals in area.

Need for control of the surrounding area

U.S Dept. of the Interior, Bureau of Outdoor Recreation, **Outdoor Recreation Research**, 1970, U.S.G.P.O., Washington, D.C.

Currently active studies involving vacation homes include the following:

- I. 2.0032, Economic Analysis of environmental quality effects associated with seasonal homes.
D.M. Tobey, Univ. of Maine, Agricultural Experiment Sta., Orono, Maine 04473

objectives: determine the environmental situations, positive and negative, associated with seasonal homes and analyse attitudes, interests and goals of people for a quality seasonal home environment. Evaluate social and private costs and benefits at regional and national level. Assess current and alternate institutional arrangements intended to correct inefficiencies and inequities in resource use in seasonal home communities.

approach: five case studies in Maine areas. Estimation of social costs and benefits generated by environmental effect.

- II. 2.0082, Economic analysis of environmental quality effects associated with seasonal homes.

H.B. Gamble, Penn. State Univ., Inst. for Res. on Land and Water, University Park, Pennsylvania, 16802.

objectives: same as for 2.0032, above.

- III. 3.0099, Economic analysis of environmental quality effects associated with seasonal homes.

M.I. Bevins, Univ. of Vermont, School of Technology, Burlington, Vermont, 05401.

objectives: same as for 2.0032, above.

IV. 2.0104. Nonresident ownership of property in Vermont.

R.O. Sinclair, Univ. of Vermont, School of Agriculture, Burlington, Vermont, 05401.

Economic analysis of all nonresident property owners of 3 or more acres in sample including 30 towns. Major share are vacation homes. (Nonresident here refers to owners within Vermont as well).

Social profiles of owners, descriptions of properties, uses of properties, income from properties, satisfaction with and desire for services are all involved in this study.

V. 3.0038, Local Government and Policy Implications of seasonal home ownership in rural areas.

R.W. Snyder, Univ. of Minnesota, Agricultural Experiment Sta., Saint Paul, Minnesota, 55101.

objectives: effort to obtain accurate detailed information by interview of random sample of seasonal home owners, on the following:

physical characteristics of property
expenditures in seasonal community
extent and nature of seasonal home use
attitude toward public services, facilities and policies

desires to demonstrate:
motivation of seasonal home owners
impact on rural community
adequacy of public policy and services

progress:
Local units, though able, are reluctant to provide public goods and services. Tax base analyses: local governments with seasonal homes have greater capacity to provide goods and services than those without. Real property and business property make up a larger proportion of property tax base in former case as well. County roads cost more for counties with seasonal homes, though not as much as fiscal capability would suggest. Highway construction needs increase with occurrence of seasonal homes. Poor roads are a complaint of seasonal home owners. School districts with seasonal homes do not spend more per pupil than those without.

The Use of Land: A Citizen's Guide to Urban Growth, A task force report sponsored by The Rockefeller Brothers Fund, New York: Crowell, 1973. (Ch. 7)

The chapter, "Subdividing the Great Outdoors," is concerned basically with recreational subdivisions, their uses, abuses, costs, and proper regulation.

In the absence of specific problems, such as consumer victimization or environmental damage, there is nothing wrong with second homes. The major problem with the present recreational land boom is that people are buying lots but not building on them. Subdividers are selling land with a high-pressure tactic that emphasizes land purchase as an investment rather than an acquisition for personal use and development. Those buyer who are interested in building on their lots immediately usually face unanticipated expense.

Because of the way in which such subdivisions are created, two basic concerns emerge:

Consumer fraud - Interstate Land Full Disclosure Act: provides 48-hour cooling off period which can be waived. Should be changed to unwaivable 30-day period, granted to buyers including those who have seen the land before they buy. ILSFDA originally was proposed to treat land investment as securities investments in the developing company. This would have a beneficial effect, as such transaction would then be under control of the Securities and Exchange Commission. Developer Warranty on the lot and its usability within a guaranteed period of time, with promise of money back plus interest, and damages would provide excellent protection.

Achieving Quality Development - Dead subdivisions on which little building has been done end up often as "rural slums" and when it later becomes suitable for urban development, scattered ownership patterns and higher prices would make reassembly of large parcels most improbable, therefore eliminating more innovative uses of the land. The necessary steps to reduce this difficulty include planning for land capacity and topography now, and taking environmental damage potentialities into account. 1) End high-pressure sales of land. 2) Base public policy on the recognition that second homes form communities. 3) Require recreational subdivisions to satisfy the same requirements and standards as first-home communities. 4) Local governments should establish requirements for all subdivision to ensure acceptable standards, and provision of adequate public facilities (installed or bonded with protection against inflation). States must act to help local governments establish proper requirement.

Discouragement of "subdivide and run" philosophy: Land must be suitable for the project proposed, and subdivider should not be allowed to show a sizable profit before he has made improvements on the entire sum of the sale when only a small down payment is made. New reporting guidelines approved by the American Institute of Certified Public Accountants require that reporting of revenues and profits by related in time to the project costs in incurs for land improvement and sales. A better method yet would be to place part of the buyer's payments in escrow until promised improvements have been made.

Expectations are for responses to such measures to be spotty. These changes should shorten time between lot purchase and lot use. Some adverse results of poor planning around lakes: erosion and sedimentation, from lawns and golf courses, fertilizer pollution, dish and laundry detergents, oil products from cars, salts from snow removal, garden chemicals. Lake may be unfit for swimming in 5 years.

The Use of Land, a citizen's policy guide to urban growth. A Task Force Report sponsored by the Rockefeller Brothers Fund, ed. by William K. Reilly, New York: Thomas Y. Conwell Co., 1973 (emphasis chaps. V & VI V II).

pgs. 227, 228, 229:

Barrington, Illinois, cost-revenue analysis.

The two variables influencing school revenues and costs were: average number of bedrooms per dwelling and average market value. Single units with less than four bedrooms and apartments with less than three bedrooms favorably impact school costs. Almost all units with more than four bedrooms cause school deficits.

Order of tax-producing uses of land:

1. Research-office-oriented industrial development
2. One/two bedroom apartments
3. Shopping center
4. Two and three bedroom apartments

pg. 264:

1971 - 625,000 recreational lots sold by 10,000 subdividers. Only one out of six lots are built on.

The Utah State Department of Community Affairs is working on a study of recreational subdivisions in Iron, Summit and Wasatch Counties, Utah. This study focuses on 10 subdivisions and deals with, among other things:

1. Tax Levies
2. Tax delinquency
3. Tax expenditures for certain public services

"Vacation homes - a boom with pitfalls" U.S. News, 73:62-4, August 14, 1972.

Two million Americans own vacation homes, increasing from 150,000 - 200,000 per year.

Not illegal abuses occur often in promotion and sales. In 1968, the Federal Interstate Land Sales Full Disclosure Act provided that developments over 50 acres must be registered, property reports for such developments be required.

Boise-Cascade getting out of second-home development business because of difficulties involved. (See abstract 11)

Workman, John P., et al., **A taxpayer's problem: Recreational Subdivisions in Utah**, 1973, Utah State U.; Logan, Utah

Rural areas have welcomed subdivisions as a means of increasing revenues. However, problems caused by rural subdivisions exceed increased tax revenues. Some problems are: inactive land due to speculation, alteration of watersheds, demand for community services to distant places. Utah has no land plan to cope with such problems.

Utah's subdivision activity is nearly equal to that of California, although the population of L.A. is 8 times that of the entire state of Utah. Population of counties with largest subdivision is not for primary homebuilding.

No control exists at present. Utah Real Estate Division has been authorized to investigate lands being offered and make a public report, but is unable to deny permits to sell even though there are critical problems with a subdivision. In many cases, water supply, drainage, roads, fire protection are nonexistent or inadequate.

Speculative use of land is encouraged by low taxes on undeveloped lots, and counties get less revenue. No analysis is available as yet on whether developments which are progressing cover their additional costs with tax revenue brought in.

Out of state ownership amounts to 86% of the lots sold in Iron Co. (Such owners of undeveloped lots pay 3% market value vs. 14% for Iron Co. residents. 1969 law provides for a complete state audit and reassessment every five years. This should alleviate loss of tax revenue.

Well-organized and informed taxpayers and proper legislation are necessary for Utah to avoid further tax burden and environmental loss.

APPENDIX III

BIBLIOGRAPHY

A. Socio-Political Impacts

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G. TIMBER AND FORAGE USES

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INTRODUCTION

Initially, Timber and Forage task force deliberations were concerned primarily with changes in and additions to the usual research programs. An initial session was conducted in four conterpoint sessions:

- I. Timber vs. forage
- II. Market vs. non-market
- III. Systems analytic vs. heuristic
- IV. Current researchers view vs. research management views

This session resulted in a statement of the following biological research priorities:

- (i) *Pollutants and Natural Assimilative Capacity*: Research needs include items such as assimilative capacity of wildlife habitats, effects of herbicides, air pollution impacts on forest fauna, and rain acidification.
- (ii) *Food and Fiber Needs*: Present methods of resource consumption are wasteful and necessitate an improved priority assessment for resource use and an adjustment to allowable use rates for renewable resources. A basis for resource management and consumption priorities could be the total energetic efficiency of production systems including energy costs of processing and distribution, fossil fuel requirements, and alternatives to fossil fuel energy inputs. Thus, energy efficiency could act as a control on energy use.
- (iii) *Fauna*: A detailed state-of-the-art on wildlife in the Rocky Mountain area is needed. There is especially an information void for non-game species (numbers, distribution, and habitat). For example, while there is unanimous agreement that tree harvesting will influence wildlife, we know little about how a specific harvesting prescription will affect both game and non-game wildlife species; one group may be improved while the other is threatened; some species within one group may be helped while others are hurt.

Continued discussion of the task group revealed, however, that many problems, and probably the dominant problems, are of a more general nature. A complete reorganization of the task group effort, beginning with these more general problem areas, comprised the bulk of the task group effort during the second session. This new effort should be entitled "Research management, land management, and research selection procedures for the utilization and identification of significant biological and physical research on renewable natural resources."

In the second session we defined our task as: *What research relating to timber- and forage-producing lands will yield the greatest benefit per unit of additional research effort expended?*

Thus, our evaluations did not attempt to ascertain which are the most important resource management problems, nor which areas have the most (or least) information. Answers to the latter question do not necessarily shed light on the marginal value of additional investments in research, which we took to be the central question.

The charge to the task group included both a report on status of existing information and needs for future research. The report which follows points out the status of research primarily by listing of typical publications in the bibliography, but no narrative literature review has been attempted. In addition to many previously published volumes, some of which are included in the bibliography, the various biome programs (IBP) funded by NSF are now preparing 40 to 50 volumes of reports covering various aspects of research on timber- and forage-producing lands. For us to attempt to synthesize such a vast array of information would have been sheer folly. We have also included in the bibliography several other papers which we feel represent the frontiers of science for the various disciplines involved and recommend a perusal of these titles to the reader.

It is the combination of a vast array of information and the as yet unanswered problems in natural resource management which gave the deliberation of the task group its central focus. The typical procedure for a research assessment project is to list a series of research interest areas. If the research interests of the scientific community are followed, we will continue to get more research in areas where there are many scientists, less research where there are fewer scientists, and no research where there are no scientists.

This report was prepared with the feeling that the research interest approach is not professionally responsible. We attempted to present a view of the present status of the various disciplines involved in a more comprehensive manner. The result largely reflects the progress of 65 years of research on timber- and forage-producing lands; it also clearly shows the significant philosophical changes in research approaches during the last five years. In order to make further progress, and in order to answer pressing research management problems efficiently, we presently have as great a need for information structures and theories as we have for additional input of biological information.

Recent attention to environmental problems has produced a state of "crisis saturation." Practically every species is either a pest or endangered, or both. Practically every area is unique or valuable in some way and thus worthy of preservation and yet threatened with changes by society. In this vast array of problems we have attempted to extract some central themes. Dominant questions include:

- (i) How can research management be improved to give a better direction in the collection and presentation of new and existing information?
- (ii) Since the array of possible research questions is infinite, how can the selection of particular research efforts be guided to improve the chances of the research being relevant to solution of land management problems?
- (iii) Of the total information needed for land management decisions, which is the most likely to be critical in the near future?
- (iv) How can existing and new information be better brought to bear on rapidly changing and unpredictable problems?
- (v) What kinds of biological and physical research activity will provide a sound yet flexible information base with which to answer the questions of the future?

I. RESEARCH MANAGEMENT

The most common concern reflected throughout the discussion session was the need for more flexible and responsive research management and more flexibility among researchers themselves. Until the late 1960's research on timber- and forage-producing lands has emphasized long-term research assignments by individual scientists in order to provide stability to research programs. In spite of the fact that these practices have given us an impressive array of background information, they have also produced an almost immovable research structure which is extremely difficult to adapt to changing problems.

In more recent years several new alignments have become more common and ad hoc research teams have been assembled for many questions. These new arrangements have sometimes brought considerable strain to established organizational concepts, and have not always produced the desired results.

It is apparent that research management procedures not only must be more flexible, but that we must learn to manage this flexibility. Reward structures for more rapid responses must be developed. At the same time, "brush-fire" programs cannot be allowed to dominate the research scene, for such programs all too frequently produce little of lasting benefit.

The task group does not profess to have a plan for perfect research management, but the fact that a problem exists is all too clear. There are some current attempts at analysis of various research efforts (e.g., Mar and Newell, 1973), and more analyses of this kind are needed.

Some specific items which could be addressed in such a program include:

- (i) How can present scientists be retrained into new areas of research or into new concepts, philosophies and research approaches, and how can this training be incorporated into a program of continuing education?
- (ii) Can research systems be restructured so that a balance between peer evaluation (by fellow scientists) and user evaluation (e.g., by land managers) can be achieved?
- (iii) How can ad hoc teams be directed and stimulated toward the early production of significant results?
- (iv) How can in-depth expertise be maintained and at the same time be rapidly utilized and redirected with changing problems?
- (v) How can current problems be expressed and brought to the attention of researchers in researchable terms?
- (vi) Can successful personnel interchanges be arranged between research groups and research users?
- (vii) What concepts are most valuable in the overall guidance of a research program?

II. MANAGEMENT MODELS

It has long been felt among scientists working on land management problems that a clearer and more quantified expression of problem areas by land managers would aid greatly in establishing research priorities; such procedures would undoubtedly also lead directly to better management. In recent years, much progress has been made in the direction of frameworks within which the land use planner can simultaneously involve biological, economical, social, and political questions in the decision process.

It has become evident that individual agencies, etc., are trying to solve the same fundamental system problems. Numerous texts and papers are available describing appropriate techniques; some of these are referenced in the attached bibliography. Simple linear programming is the most widely used operations research technique; the largest positive merit of this procedure is its ease of application to a wide variety of real-world problems. Linear programming solves one of the basic problems of natural resource managers; it provides a simple method for the optimal allocation of scarce resources among competing activities.

Linear programming is based on the standard procedure of maximizing or minimizing an efficiency criterion. The technique provides an efficient means by which a manager can quantify variables and obtain an optimum combination

of a particular resource bundle based on predetermined objectives. The four basic assumptions of linear programming (linearity, non-negativity, certainty, and continuity) can be considered as both merits and disadvantages. The merits include a relatively simple problem formation. The disadvantages are that the assumptions may be overly restrictive.

Both deterministic and parametric forms of linear programming can be used as tools for natural resource decision analysis. Parametric linear programming allows varied requirements to enter into the problem to enable comparison of the change in the optimal solution given the changing requirements. This procedure, therefore, seems to have advantages over the normal static deterministic linear programming model.

Sensitivity analyses are performed to find out how much various constraints can be changed without changing the point at which the optimal solution to the problem occurs. Such analyses lead directly to a consideration of critical information inputs.

Methods for incorporating parametric linear programming and sensitivity analyses of linear programming into land management planning are fairly widely available (e.g., Reid, 1972; Kaiser et al., 1972). New developments need to include means of better representing probabilistic events and dynamic problems. Most especially, the problem of non-additive objectives needs to be more fully addressed; goal programming (Lee, 1972; Field, 1973) offers much help in this regard. Sensitivity analyses and probabilistic approaches for goal programming need to be developed. Whatever approach is used needs some form of sensitivity analysis in order to assess information priorities.

Simulation models (e.g., Forrester, 1961, 1968) are also useful and used for particular management questions. A further discussion on simulation models is included in Section IV.

The primary difficulty with application of any operations research, systems analysis, or management science technique, however, is not the methodology involved, but the people who are involved in the use of the techniques or are recipients of the tool. One group includes a large number of people who believe that a particular methodology is the ultimate technique to the solution to all problems. Another group is primarily the skeptics and uninformed. The latter group requires patience and extensive explanation from the management scientist in order to elicit some level of understanding and acceptance.

We need simpler and easier-to-use packages and better explanation of such models if potential users are to be encouraged to use them. Along these same lines, statements pertaining to application and use of each model, and the credibility and reliability must be stated for user confidence.

Many management models or operations research techniques are available, but need development so that land managers are more able to use them with a minimum of specialized training. Matrix generators and report generators are a good start in this direction.

One way to improve application of existing models is to provide incentives for researchers and model developers to communicate with potential users. This might be accomplished by presenting seminars, workshops, conferences, continuing education programs, or by an "extension" service. Any activity must be a two-way affair with managers stating explicit problems and management science specialists formulating and presenting models which will help solve these problems.

The assumption of additivity in the efficiency criteria of linear programming has been a serious problem; relaxation of this assumption with the newer procedures of goal programming has been a great benefit. With this procedure, multiple objective functions can be handled. Goal programming at present lacks the sophistication of sensitivity analysis and matrix generation procedures available in linear programming, and research toward solving these deficiencies needs to be pursued.

Specific questions include:

- (i) How can allocation models be made more useful to land managers, administrators, and educators?
- (ii) How can non-market attributes be better incorporated into land management decisions?
- (iii) How can requirements for and results from such managerial models be better utilized to express needed information on physical and biological components?
- (iv) How can training programs be better developed so that land managers can better state their management problems and thus better state their research needs?
- (v) How can such models be kept flexible so that they become a tool for better public understanding and public involvement?

III. SOCIAL VALUES OF BIOLOGICAL RESOURCES

Even with the short and rather limited history of the application of quantitative decision analysis models to timber- and forage-producing lands, it is becoming obvious that information about social constraints, requirements, and values often is more critical than information about the physical and biological resources. These social attributes need to be explicitly included in management considerations. Unfortunately, the general trend of many social science disciplines does not lead in this direction. It is apparent that new directions with inputs from the land managers and individual citizens are needed to attack more relevant research problems.

A common concern among biologically trained researchers and land managers is that the lay public be better educated so that "better" land management can be achieved. This assumes that some biological states are inherently preferable to other states. An alternative view is that "goodness" is a property of human judgement. The problem then becomes one of discerning these human values rather than of education.

Any society, however, can make clearer judgements if informed of the probable consequences of their actions. In the next section the work group's views on how to accomplish such understanding will be presented.

We feel that research into human attitudes and behavior is not receiving sufficient attention in environmental research. Such information is critical because land management decisions very often revolve around social aspects as well as biology. If the social constraints, requirements, and goals are limiting to the managerial decision processes, it is impossible to judge which biological information is most important.

To the scientist trained in biological and physical sciences, it appears that a major influence of social values is in the area of landscape esthetics. Questions of esthetics have led to major conflicts between food and fiber production and recreational uses. Esthetics, like recreation, have assumed increasing importance in recent years primarily because of increased environmental awareness. Esthetics research, however, has generally lagged behind recreation research, no doubt in part because esthetics are less tangible and contain even more confounding variables than recreation. The current interest in esthetics from a management viewpoint is reflected by the large number of applications of various techniques of esthetics measurement. The need for a systematic approach to handling this management dimension is recognized, but many managers have opted for new or existing techniques of questionable scientific virtue because of the pressures to include esthetics along with other, more tangible, wildland products. Another reason may well be the low quality or lack of scientific objectivity of available approaches; quite often, for example, techniques rely on arbitrarily determined weights for various landscape features.

Techniques purporting to measure scenic quality or landscape esthetics are numerous, but no generally accepted technique or approach has emerged (Daniel, Wheeler, Boster and Best, 1972). Litton has made substantial contributions to the field of landscape esthetics and design. The Forest Service, as the nation's largest employer of landscape architects, has expanded on Litton's pioneering and continuing work (National Forest Landscape Management). Although these design-oriented criteria and guides are quite useful to landscape architects, there are two main drawbacks: (1) the criteria lack empirical verification,

especially as to the relative importance of landscape features, and (2) they do not easily lend themselves to unbiased evaluation of vegetation management alternatives. There is a real need for a more coordinated effort toward more objective handling of landscape esthetics while at the same time recognizing the many possible approaches to the problem.

A major concern in land management is the social values to individuals and groups who are only remotely involved with particular management problems. We have termed these values "vicarious benefits." These benefits and costs have special meaning to managers who receive feedback from "armchair naturalists" and the like. Such persons generally pay (through taxes) the same as users for semi-primitive land management. Much has been written in philosophical tones of "knowing what's out there" (vicarious feelings). It is not sufficient to react only to users; there exists a need to identify management-related opinions of those non-users and occasional users of semi-primitive lands.

These opinions are management information inputs which can only be obtained by sociological sampling. Therefore, the art and science of questionnaire design is a critical component for the assessment of vicarious benefits and costs. Weisbrod's notion of "option demand" (Weisbrod, 1964) as discussed by Krutilla (1967) may be an especially valuable concept here. Many recreation-oriented surveys may, in fact, be measuring vicarious values. Closely tied to assessing public preference is the need for the public to understand the real options. This notion, of course, transcends all non-market topics.

Specific questions include:

- (i) What biological and physical attributes lead people to move to particular areas, or at least recreate in these areas?
- (ii) If the reasons for moving are open space, undisturbed landscapes, and mountain scenery, will land management practices influence this behavior?
- (iii) How can social values concerning land decisions be better expressed?
- (iv) How can social considerations be presented so that they are better understood by land managers and by biological and physical scientists?
- (v) What are the interrelationships between production of market goods and non-market values?
- (vi) To what degree are non-market values predictable? If they are unpredictable, how can they be treated?
- (vii) What progress can be made in quantifying non-economic social values of biological resources?
- (viii) How do cultural changes influence demands on timber- and forage-producing lands?
- (ix) To what degree are various demands consistent?

IV. INFORMATION SYNTHESIS AND MODELS OF BIOLOGICAL AND PHYSICAL SYSTEMS

We are faced with vast amounts of available information; at the same time we realize that questions asked by users of research information very frequently cannot be answered rapidly enough or clearly enough to be helpful. To solve this problem, the Timber and Forage Task Group urges that considerably more effort be given to methods of assembling, interpreting, and displaying information. Although there may be other techniques which can and should be developed, recent progress in computer models of dynamic ecological systems has certainly been a very useful asset in this regard. In particular, those models in which biologists can see the need for and insert their own information about biological processes have been most helpful. Although experimental biologists are prone to chorus "but we don't know enough yet to build such models," it has been demonstrated that very frequently enough information is known to help in predicting the consequences of management alternatives.

The output of such models should be directly useful in the decision analysis methodology of Section II. The particular questions of land managers should be answerable by the models; however, models which are in the conceptual or developmental stages are useful in guiding research direction but have little usefulness for managerial decisions. A direct coupling between models of biological and physical systems and the decision analysis process is necessary so that appropriate sensitivity analyses can be made.

It has repeatedly been shown that traditional research cannot produce answers rapidly enough to be of real use to the manager; thus a real argument in favor of modeling approaches is that the alternatives are unacceptable.

Although considerable progress has been made in the past few years in making model building both easier and more useful, much remains to be done. We need to strive to reach a point in modeling capability at which concepts and basic knowledge of biologists and physical scientists can be translated into information for managerial decisions without being unduly inhibited by mathematics and computers, yet remain free of biases and misunderstandings. We believe that it is possible to develop such capability, but the effort will not be a small one.

Some specific questions include:

- (i) Can simulation models be developed to investigate ecological questions and principles such as diversity, stability, and productivity?
- (ii) How can structuring and input devices be built which will ease the development of models by biologists and physical scientists?

- (iii) How can output and interrogation devices be built which will ease the manager's use of models and model systems?
- (iv) Can models be developed so that they are useful in many geographic areas other than where they were originally constructed?
- (v) How can interactions be expressed other than Leibig's law of the minimum and multiplicative factors?
- (vi) How can sensitivity analyses of simulation models be developed to better define basic research needs?
- (vii) Are there dangers that models will be accepted without adequate challenges as to their validity? How can such dangers be overcome?
- (viii) How can modeling activities be legitimized as a scientific endeavor?
- (ix) Can systems which build models be developed?
- (x) What inducements will make hardware free (i.e., non-machine specific) model building more attractive?
- (xi) Can a formal meta-language be developed for describing and thus facilitating the structuring of models (e.g., Backus Normal Form which was developed to describe ALGOL 60)?
- (xii) How can linkages between subsystems best be formulated?

V. BIOLOGICAL AND PHYSICAL RESEARCH

In this section we analyze types of biological and physical research which appear to have the greatest profit per unit of investment. We especially will look at the difference between process studies and state variables or inventory studies. The difference between processes and states of a system has been clearly emphasized in ecological research of the past few years; the states of a system refer to the status of the system at a particular point in time. As such, the states depend on a wide variety of conditions. For relatively unchanging parameters, such as soils, geology, topography, etc., state variable information can be helpful for a considerable length of time. For more transitory parameters, such as plant and animal populations, state variable determinations soon become outdated. If the time required to obtain state variable information is great, and the useful life short, such measurements may not be worthwhile.

The difficulties with state variable or descriptive studies leads to the conclusion that a more fundamental approach is necessary. Thus an assembly of basic processes, arranged in a system which can produce state variable results rapidly and inexpensively, meets the criteria of both the scientific community for basic and stable research programs and the criteria of managers for the rapid production of information.

A process study in this context is one which has as an output the change of a variable per unit of time. Various other parameters obviously control the rate of change, and the determination of the relationships of control parameters and output parameters makes up the field of process studies.

Since the basic biological and physical processes are valid generalities over a wide range of conditions, a library or reservoir of process information can be accumulated. Properly designed, such a library can be drawn upon in many assemblages to produce estimates of state variable information required by managers.

Because of the power, flexibility, and long-lasting usefulness of process studies, the task group urges that priorities for future biological research be directed toward process studies. Examples of process studies which have been successful include studies of mineral, water, and nitrogen cycles. Energy and carbon budgets have been more difficult and need to receive more emphasis in the future; other approaches to processes also need to be undertaken. In particular, population processes such as regeneration (or births), growth, and death (or mortality) need to be addressed. Processes of ecosystems viewed as simultaneous properties of many populations are an especially critical area because there is at present an inadequate conceptual base for multi-population problems.

In particular, the belowground parts of ecosystems are much less understood than the aboveground parts. The belowground components are primarily responsible for much of the buffering, filtering, and stabilizing action of ecosystems, and thus they need to be understood for a better evaluation of long-term effects of management practices.

Such a broad research strategy will, in the long run, be more productive than a series of state variable measurements. Various short-run questions will undoubtedly arise, however. Immediate questions about traditional market products (food and fiber) can often be answered from existing information, but other questions, such as for non-game fauna and many aquatic species, cannot be so readily answered. Although we recognize the problems of treating such short-run questions, we are unable to predict which questions will be next on the critical list, and thus cannot prescribe a research priority to deal with these questions. Because of the transitory nature of such problems, we suggest that a register of educators and researchers qualified to do short-term inventories be maintained, but we cannot recommend which short-term inventories should be a central part of a research strategy.

Examples of specific questions include:

- (i) What are the reproduction, growth, and mortality rates of important food- and fiber-producing species, and how are these rates controlled by environmental factors?
- (ii) What is the impact of harvesting rates on the processes which determine nutrient and carbon balance of ecosystems and subsequently on system stability?
- (iii) What are the biological and physical functions of the underground components of ecosystems which provide ecological stability?
- (iv) What is the relationship between carbon, nutrient, and energy budgets for ecosystem stability?
- (v) What are the basic processes involved in multi-population systems, and how do these processes relate to the probability of survival of individual species?
- (vi) What population characteristics determine the response of populations to impacts? How can these characteristics be used to predict whether or not a species is endangered?
- (vii) What are the impacts of new influences, such as air and water pollutants, on ecosystem processes?
- (viii) How can interfaces between subsystems be studied in a process framework?

SUMMARY AND CONCLUSIONS

A research assessment workshop, we have found, is easily led astray by several related, but nonetheless distinct assessment problems. Among these are the most important resource problems of the present or future, areas of the greatest abundance of knowledge, areas of the greatest deficit of knowledge, and an appropriate sequence of events in addressing a scientific problem.

The real job of research assessment is, we feel, none of these. The task is to approach the problems from the standpoint of limiting factors or marginality. We define our task thusly:

What research relating to timber- and forage-producing lands will yield the greatest benefit per unit of additional research effort expended?

Thus, highly critical resource problem areas may not be high priority research areas if there is presently adequate information to solve the problem. Areas of little information may not be high priority areas if there is no particular need for the information. Our report, therefore, does not develop a priority of resource management problems or a scale of information abundance. Instead it looks at probable research payoffs.

Research is conducted because of the possible immediate or potential benefit to human welfare (note that we avoid a definition of human welfare). If the results of research will, the near or distant future, become a critical element in decisions about practices which influence human welfare, the research is necessary within the concept of marginal benefits.

We are unable to predict the critical elements of information which will be needed in the distant future. We are essentially unable to do so in the near future. We do know, however, that research priorities change rapidly from time to time and from place to place. Unfortunately, our research organizations are frequently unable to respond to such changes in priorities. Existing research approaches often produce answers to problems only after they have long since ceased to be priority questions. We therefore place in our priority list the problem of *development of more responsive research management procedures*.

Since research into management methods was not the forte of the task group members, we have not suggested research approaches into this question. We do affirm, however, that more responsive research management is needed in order that research can be continually reevaluated for appropriateness.

Given an optimal research organization, however, the question of "which research" is still not resolved. For land management problems, research problem selection will not be clarified until methods of analyzing decisions are utilized which allow, or demand, a clearer specification of information needed.

Although it is more of a development problem than a research question (because many useful techniques are presently available), we nevertheless must place a high priority on *development and utilization of decision or allocation procedures which will allow analyses to determine critical elements of information*.

Such procedures should include consideration of goals; fixed constraints; physical, biological, and social responses; and management alternatives. Necessary basic tools are generally available in the literature on operations research and related areas, but a great deal should be done to make these tools more useful and more used in land management decisions.

The procedures should provide a mechanism for allowing ready realization of the consequences of various priorities by communities, regional populations, and other social groups. Thus a training effort is required to get such tools into common use, and use of the tools in turn provides a viable and instructive training device.

We expect that, if such procedures are widely used for determining limiting factors, the most critical elements of information influencing land management decisions will often be in the social constraints and social value judgements within which the land manager must operate. Preliminary examples in both public and private land management indicate that this is indeed the case. Until the constraints and judgements are adequately incorporated in the analyses, it is impossible to detect whether information about the biological and physical system is critical or if the problems concern values about biological and physical systems. We therefore, place in our priority list *development of methods of determining social constraints and social values which impact on land management decisions*.

Research in this area has recently been initiated along several fronts including social value indicators, visual perception studies, interactive public involvement procedures, etc. We urge continuing effort in these areas coupled with training so that appropriate results can quickly be brought into practice.

Only after the above problems are taken care of can we begin to assess biological and physical information critical to decisions. We do know, however, that although the questions will change frequently, the basic problem for biological and physical research on timber- and forage-producing lands will be of the nature, "if we implement this alternative, then what will be the response?" The responses which need to be evaluated for each alternative include market product yields, non market responses, and energy and monetary costs of implementing the alternatives.

Previously it has been a common research practice to perform field experiments to answer questions about each management alternative. Frequently, one or more of the necessary criteria for full evaluation have been omitted. Even in the best of cases, results have usually not been available until long after the alternative ceased to be viable. To accelerate the ability to answer such questions, and to make the responses more comprehensive, new procedures must be developed.

Recent growth in mathematical and computer models has given a great assist in this area. Although model building often appears to be expensive, time consuming, and perhaps wasteful in the sense that not all models are useful, these efforts should be compared to alternative learning methods, such as field experiments, for a better evaluation.

Repeatedly it has been found that information availability alone is not sufficient in evaluating management alternatives. (Note that delayed but more precise information likely will have less impact on the decision processes.) Often the difficulty is to organize, interpret, and evaluate the information.

Because of the need to produce early, even if approximate, evaluation of a host of as yet unspecified management alternatives, we must place in our priority list *development of a battery of models and efficient modeling procedures which can indicate probable responses to a variety of management alternatives.*

We caution that the development of models not fall into the same trap that experiments have in the past; i.e., model development and utilization must be rapid enough that the results will be useful. Many present modeling activities appear to be never-ending; i.e., the model builders repeatedly find reasons why the model is "not good enough yet" to be used in management questions. We emphasize that a model, like an experiment, gives only approximate information and endless refinements are self-defeating.

Although model building has been greatly facilitated in the past few years, there is still much that can be done to make model building faster, cheaper, and easier to comprehend. To this end, research in systems which build models should be pursued.

The above items will greatly assist in assessing research needs in the biological and physical sciences. We know in general, however, that:

- (i) The critical elements of biological and physical information will vary widely depending on specific questions to be asked and the conditions under which the questions are asked. The combinations are essentially infinite in number, and a reservoir of ready-made answers is essentially impossible to assemble.
- (ii) Although experiments based on determination of state variables may give rather precise information, the results are specific to a particular set of circumstances. Much more generality and flexibility is achieved with results of process studies which can be assembled into models to give approximate results with much earlier delivery times.

This flexibility to answer a variety of as yet unspecified questions is a most important point. Although the critical processes cannot be exactly specified *a priori*, the number of important processes is at least finite. Thus we urge that biological and physical research be designed to feed information to model, and that priority be given to *development of research programs which emphasize basic biological and physical process information to be incorporated into a variety of models for answering specific managerial questions.*

Great success has been achieved recently in sets of process studies built around cycles and budgets of energy, carbon, nitrogen, mineral elements, etc. Continuation of this type of research, with perhaps greater emphasis on energy and carbon budgets, is urged.

Particular shortages of process results are apparent in the belowground parts of ecological systems. Since the belowground parts are most important in providing filtering, buffering, and stabilizing action to the ecosystem, these processes are important in assessing long range impacts of managerial practices.

Various aboveground components of ecosystems are more directly related, however, to both market and non-market evaluations of ecosystem responses. Presently we are best able to answer questions about market attributes (such as food and fiber production) and least able to answer questions about non-market attributes (such as non-game fauna, esthetics, etc.). We are unable to specify in advance, however, which of these elements of information would be most critical for a given decision.

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TIMBER-FORAGE TASK GROUP REPORT APPENDIX

In the introduction of the report, general problem areas were stated, and in the last section, the use of basic ecological process information toward the solution of these problems was outlined. Appendix Table 1 is a list of basic processes which form a basic structure for more complete understanding of timber- and forage-producing lands. Forty-four basic rates are identified, and perhaps another five or ten could be added. Availability of this information is required for the basic understanding of critical phenomena which is necessary to answer a multitude of management questions.

An appropriate list of rates is different than a list of questions or problems to be answered or solved. For an example of the latter see Appendix Table 2. The operational methodology is to take information such as that in Table 1 to answer questions such as those of Table 2.

The list itself is perhaps deceptively simple. For each rate in the list, factors controlling the rate must be carefully studied. For example, evaporation rates will depend on soil water content, radiation, plant cover, the soil's physical characteristics, etc.; photosynthesis is controlled by radiation, temperature, plant water content, leaf area, etc.; food intake is controlled by animal size and food quality; infiltration rates may be controlled by number of recreation visitors, and visitors may be influenced by numbers of plants and animals. Each rate has its own control variables, and the relationship of the control variables to the rates must be understood. The number of control variables may average about five for each rate. For successional studies yearly rates are appropriate, but for intra-seasonal dynamics daily, weekly, or monthly rates are needed.

In addition, many of the rates vary for each plant, animal, and nutrient species; in these cases separate studies are needed for many species until enough information is obtained so that general patterns begin to become evident.

Research programs should be designed to systematically study these rates, but priorities for the various rates are difficult to establish unless sensitivity analyses are concurrently being made to determine in which cases information is most critical.

These lists have been assembled from many modeling efforts in the Rocky Mountain area, including models for hydrologic parameters (3), timber growth (2), plant succession (2), forage growth (3), animal nutrition (2), population dynamics (3), soil nutrients (2), and recreation visitors (2). Although the lists are undoubtedly not complete, they do represent a very sizable undertaking, and even development of approximate values for each rate (complete with control variables) could lead to significantly improved understanding of the biological and physical processes which determine renewable resources.

Each rate will require a considerable scientific effort. In some cases the work may involve primarily a literature review: when this is so, about one-half professional year is an appropriate time allocation. In a few cases extensive experimentation will be needed; perhaps twenty professional years will be required for some of the more difficult cases.

An estimated effort can perhaps be roughly computed as follows:

Hydrologic parameters

12 rates X 10 years each = 120 professional years

Soil nutrient parameters

5 rates X 5 years each X 10 nutrients = 250 professional years

Recreation visitor parameters

6 rates X 10 years each = 60 professional years

Timber and forage plants parameters

11 rates X 6 years each X 50 species = 3,300 professional years

Animal parameters

10 rates X 6 years each X 50 species = 3,000 professional years

Total = 6,730 professional years

A total effort of 6,730 professional years at \$60,000 per year would require \$403,800,000; at the present research funding levels in the Rocky Mountain area about forty years would be required for the necessary experiments. It is obvious that research funding must be significantly increased in order to complete the needed information within a reasonable time; a four-fold increase would allow the work to be done in ten years.

Although the amount of effort required to obtain information on 44 basic rates or processes may appear astronomical, let us consider the alternatives. Rates such as these combine in a wide variety of circumstances to produce conditions or states of various ecological systems about which information is needed to determine managerial actions. Direct measurement of the states or conditions, because there are so many, would be more expensive and, in addition, has much less transferability to new situations.

Assume a ten-year research program to obtain rate or process parameters would cost \$403,800,000, and that the combination of rate parameters yields $44 \times 10 = 440$ useful state variable estimations. Further assume that it costs only one-fifth as much to make a state variable measurement as it does for a good rate or process study, thus direct

determination of the 440 state variable measurements would cost \$8,073,000,000. Since each year is a different situation, however, the state variable measurements must be repeated until a statistically reliable figure can be determined. If twenty years of state variable sampling are required, the measurements would cost \$161,520,000,000 over a twenty-year period or 400 times the cost of the process study approach. This amount is also 15,000 times the current research budget. It is, of course, a very conservative estimate that we will need only 440 state variable determinations in the Rocky Mountains over the next ten years; in one area alone scientists studying the ecosystem concluded that 166 state variables should be measured to "adequately" monitor the system.

It is possible to use an entirely different approach, and that is to maintain a cadre of scientists capable of moving quickly into various high priority areas on short notice. Using this strategy, the important aspect of a research program is not so much the subject matter of the research but rather how well it maintains scientific flexibility and capability. A cadre of 440 state variable measurers would cost about \$26,400,000 annually to maintain, or about 2.5 times the current research budget. Thus the effort required under this strategy is to maintain a large stand-by reserve of generalists.

Even if the above estimates are off by a factor of 100, it is clear that the rate or process study approach, perhaps supplemented by a cadre of generalists, is the most cost-effective in the long run. Together these two strategies require 6.5 times the current budget. It will require large increases in soil, plant, and animal research, and moderate increases in other areas, but is at least nearly feasible.

Problems remain, however, in implementing the process approach and in determining priorities of studies to be undertaken. These problems include the following:

- (i) Research organizations are generally geared to other approaches.
- (ii) Land management decision frameworks are generally not structured so that critical information areas can be readily identified.
- (iii) Critical information areas are often sociological rather than biological phenomena; i.e., situations are critical because we define them as such or our actions cause them to be critical.
- (iv) Conceptual structures; i.e., models, are infrequently employed to effectively assemble the available information.

For a more detailed discussion on these four problems, see the main body of the task group report.

Appendix Table 1. Biological and physical process information for timber and forage producing land.

Hydrologic and Related Parameters

Snowmelt
Precipitation
Interception
Evapotranspiration
Subsurface flow
Infiltration
Overland flow
Interflow
Channel routing
Flood plain routing
Radiation
Sediment movement

Soil Nutrient Parameters¹

Fixation (nitrogen only)
Soil pool to labile
Root uptake
Root-shoot translocation
Nutrient losses

Animal (Domestic and Wildlife) Parameters²

Metabolic losses
Egestion
Food intake (by food species)
Conception rates
Pre-natal mortality
Birth rates
Sex and age specific mortality
Harvest and wounding loss (game animals only)
In migration
Out migration

Recreation Visitor Parameters

User arrivals
User balks
User movement to attraction sites
User stay lengths (departure rates)
Hunter successes
Fisherman successes

Timber and Forage Plants Parameters³

Growth rate⁴
Live to dead transfer (herbaceous plant plants)⁴
Loss rate of dead plant parts⁴
Photosynthesis⁵
Respiration of aboveground parts⁵
Translocation⁵
Respiration of belowground parts⁵
Regeneration⁴
Mortality⁴
Decomposition of dead plant material
Resorption of dead plant material

¹Rates for each nutrient except as noted otherwise

²Information required for each animal species

³Information required for each plant species

⁴Information required for gross models without consideration of internal physiology

⁵Information required for detailed models with consideration of internal physiology

Appendix Table 2. Types and frequency of needs expressed by land management agencies¹

Subject	Frequency
Scenic and esthetic evaluations	52
Prediction of ecological impacts of various land uses	40
Land use allocation	37
Multiple resource mapping and inventory systems	30
Water quality standards and monitoring	11
Hazard mapping	9
Waste disposal and disturbed area reclamation	9
Product management, license control, transportation control	1 each

¹This table is the result of a survey conducted among land management agency personnel by George Fosdick and James Meiman, Colorado State University, as part of a McIntire-Stennis funded project.



H. WATER RESOURCES AND USES

Task Force Leader: Jay M. Bagley



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A Report of the

TASK GROUP

on

WATER RESOURCES AND USES

a contribution to the

Rocky Mountain Environmental Research Project

-Quest for a Future

July 1974

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This report of the Water Resources and Uses Task Group is one of seven such reports prepared under the "Rocky Mountain Environmental Research -- Quest for a Future" project. The project was sponsored by the National Science Foundation (RANN), the U.S. Forest Service, and the Environmental Protection Agency. It is under the collaborative management of the Eisenhower Consortium, the Institute of Ecology and Utah State University. The individual Task Group reports constitute the basis of a final comprehensive report aimed at identifying and evaluating problems of the Rocky Mountain Region associated with the growing interaction of people and natural environments. Through this evaluation process, a documentation of presently available methodology and technology, together with an identification of information gaps and research needs are outlined. The implementation of best methods and technology, together with the initiation of critical research needed to solve certain problems, provide the necessary basis for environmentally sound resources management in the future.

Time and resources did not permit the Task Group to make an exhaustive appraisal and evaluation of water resource problems. Group members drew heavily on their own backgrounds and experience in making general assessments of current status as well as in identifying research needs. Group members also drew liberally from the expertise of colleagues and associates in preparing their individual contributions. Members of the Task Group are:

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INTRODUCTION

Water problems of the Rocky Mountain Region are probably as diverse, complex, and intense as could be found in any region of the United States. They are written in the economic and social history of the region. They stem from, and change with, the social aspirations of those living in the area as well as those residing elsewhere and having interest in the vast economic and recreational resources of the region.

Early water development of the Rocky Mountain Region was for the purpose of satisfying rather basic needs such as food (water made production more certain and permitted greater crop diversification), health (safe drinking supplies and sanitary disposal of wastes), safety (from floods), mining (extraction of valuable minerals), and energy (hydroelectric power production). For many years, meeting the steadily growing needs for these rather fundamental requirements was the major water development concern. Over the years, however, many new uses were added to the array of existing water uses. As water needs were met for the basic pursuits on a rather firm basis, increasing recognition could be given to satisfying other demands for water which could provide improvement in the quality of living. Consequently, the value of water in such uses as recreation, esthetics, and maintenance of biologic functions began to increase relative to traditional uses. The combination of an expanding array of options for water use and the changes over time in the relative social values placed on those use options has led (inevitably) to periodic water reallocations and changed perceptions of what constitutes desirable development patterns.

While we cannot overstate the importance of maintaining a healthful, pleasant environment with a wide diversity of socially desirable opportunities for resource use and enjoyment, it cannot be achieved by an either/or adoption of the "development" or the "preservation" philosophy. Rather, there must be developed a set of guiding principles for planning/management of resources and a set of evaluation procedures which exposes the tradeoffs and thus assures adequate environmental attention to any proposed development program. As the National Water Commission has said, "Good planning and imaginative design often can allow for economic growth while preserving or enhancing environmental quality . . ."

^{*}"New Directions in U. S. Water Policy" from the final report of the National Water Commission, 1973.

Uncertainties of Predicting Future Needs and System Impacts

Over the years, and in response to expressed social demands, numerous dams, diversion works, aqueducts, hydroelectric plants, and other facilities have been built in the Rocky Mountain Region. In general they have accomplished the major purpose or purposes intended and thus served the Region well. Commonly, however, they have created other problems, some of which could only have been avoided with a better awareness of cause and effect relationships; others were accepted from the outset as expected losses outweighed by expected benefits. The anticipated consequences of water development have their root causes in two kinds of predictive deficiencies which plague planners and designers in any period. One of these results from the uncertainty associated with forecasting society's future needs and preferences to specified points in time. Social objectives are dynamic, and the longer the forecast into the future, the wider the band of error associated with the forecast curve. Secondly, predicting the effects of a particular physical perturbation through a complex ecosystem (of which the water system is an integral part) and ultimately to the social end point is extremely difficult. This is because the understanding needed to describe and relate all the elements and processes involved in the hydrologic, biologic, geophysical, economic, political, legal, and social systems and their interaction with each other in one grand matrix is lacking. Because the physical and non-physical systems are so complex, and their linking relationships so little understood, the many side effects and subtle changes occurring as a consequence of triggering a change to satisfy a specific goal are difficult to predict.

Reallocation Inertia

Water reallocations between individual users take place regularly and normally through the free market process. Yet, there are many factors which slow or constrain these shifts so that reallocation may lag behind new social preferences that occur over short periods of time. The interaction and interdependency between and among a growing number of social interests to be served by water, and the number and complexity of political and institutional entities involved in the planning, development, and management of water, results in more difficult communication processes and slows the resolution of issues. Users are apprehensive about any change in a given water reallocation pattern until and unless they are reasonably sure that they will suffer no ill effects as a consequence. It is important that physical, ecological, economic, and social impacts be accurately assessed because of the tremendous investments by various sectors and the difficulty of reversing

allocation patterns once implemented. All the long-life physical structures together with the legal, institutional, organizational, and financial appurtenances associated with obtaining water for particular purposes have substantial inertia to sudden change. Achieving a rapid reallocation of water uses is like trying quickly to change the momentum of a massive flywheel. The very recent and sharp interest in the expansion of food and energy development of the Rocky Mountain Region may presage a wrenching reorientation of social values which could, in turn, cause some hard choices about alternative uses of resource and subsequent water allocation patterns and future water development.

All Water Presently in Use

The variety and magnitude of today's water uses make it virtually impossible to identify an "unused," "surplus," or "wasted" supply. True, individuals set differing values on specific uses. For example, some would cite water consumption by phreatophytic vegetation as useless, while others would see considerable value in the scenic and wildlife advantages that such water use stimulates. But whether the use is for fish production, recreation, power production, irrigation, or esthetic attraction in a primitive setting, it is clear that water allocation and development does not involve making water useful where it was formerly useless. Rather the problem is one of choice between competing socially desirable uses. The challenge is to compare all uses (including in-place uses) within the framework of social preferences as best they can be identified, and strive to maintain a balance which most fully serves the goals of society. Water resources are limited, and continuing sustained effort must be made to maintain and, indeed, broaden the utility of this scarce resource.

Extending the Utility of Water

If the premise holds that all water is presently in use and all uses have some social value, then meeting growing and changing water needs hinges on extending the utility of existing supplies. All kinds of "water saving practices" have been emphasized which purportedly would accomplish this goal. Suffice it to say that many of these water saving ideas are simplistic and individualistic and fail to regard the multi-dimensional and non-homogeneous nature of water use and cost vectors as well as the complex space and time components of water resource systems. While it may seem axiomatic that if water can be used more efficiently, additional supplies would automatically become available for other uses, it must be remembered that efficiency terms are merely an index to individual practice. Because of return flow phenomena, individual situations cannot be extrapolated linearly to an aggregated or regional use. Extending the utility of water requires appreciation of the relationship of individual to aggregated uses in a river basin sense and to the related economic, quality, legal, and institutional

dimensions as well.* Nevertheless, the concept of extending water's utility, properly applied, should be a foremost guide for planning, development, management, and also research. Consideration of alternative futures in planning or commitment of resources in development should certainly pay attention to the principles embodied in extending the utility of water. These might be stated as: (1) minimize depletions (evaporative losses not subject to recapture and reuse) wherever possible thereby maintaining a greater manageable supply with subsequent potential to satisfy more uses; (2) generally preserve, protect, and improve water quality thereby retaining its usefulness to a wider variety of potential users; and (3) make carefully considered allocations thereby assuring multiple duty, more optimal sequencing of uses and shifts in use, to conform to current and projected social preferences. These principles hold regardless of whether there are shifts in social goals or national priorities and their implementation will reduce or retard incompatibilities between and among users.

The Trade-off Axiom in Water Use

Each water use has its own tolerance limits in terms of quantity, quality, timing, and location. The natural hydrologic system within which all uses occur is too erratic in behavior and too restricted in location to meet more than a few of the uses essential to the attainment of specific social goals. Consequently, some modification of existing flow patterns is generally a prerequisite to providing supplies in conformity with the time, space, and quality requirements of particular use options. But because of the hydrologic unity that exists in any river basin (all waters in streams, lakes, underground, etc., interconnected and interrelated), any alteration of flow characteristics at one location transmits the effect of that change (ranging from imperceptible to extremely large) to downstream points. Thus, regulation and diversions from a given water course to accommodate some use have an impact on other sequential users. Also, there is generally a secondary impact as the effluent from a use is returned to the system having undergone some additional changes in quantity, quality, and regimen within the use process itself. It is easy to see, therefore, that water allocated to a specific use may preclude other uses in the same hydrologic system because of the depletive effect or the quality degrading effect projected to other points where potential uses exist. It is apparent, then, that when any

*For a more complete discussion the reader is referred to "Extending the Utility of Non-Urban Water Supplies" prepared for the National Water Commission and distributed by the National Technical Information Service, U. S. Department of Commerce.

given set of social goals get translated into a set of water characteristic requirements (quantity, quality, and regimen) the new water equilibrium may turn out to be contradictory and counterproductive with respect to other social goals. Even non-uses, or those in-place uses that require water to be maintained in its natural state or for preserving "biologic naturalness," impute an "opportunity foregone" cost by precluding those uses depending on some modification of the water regime. Thus, there are no "free lunches" where water uses are concerned. The interaction among and between water uses results in some uses being benefited and others being damaged as the hydrologic system is altered. Where the water system is not altered but preserved in its natural or existing state, the trade-off axiom still applies because other legitimate uses must be sacrificed unless the flow can be manipulated. Some examples might illustrate this trade-off concept.

Storage reservoirs create new environmental conditions for organisms and may foster new ecosystems. The change may result in a loss of biologic diversity and stability. Or, if the system is as diverse as before, some segments may be lost and replaced by others. Another possible effect of a reservoir is a change in the location or distribution of nutrients. A reservoir may act as a nutrient trap, holding nutrients which otherwise would be carried downstream; thereby increasing the nutrients behind the dam and reducing them downstream. Historic, archeological, scenic, or other values may be lost; or, on the other hand, they may be made much more available to the citizens to whom they belong. Land use may be significantly affected as the result of reservoir construction. Productive lands in reservoir areas may be inundated. Lands protected from flooding as a result of impounding peak flows may be converted to a more intensive use. Lands provided with a timely and ample water supply may be converted to intensive farming or to residential uses. Reservoirs may result in more intensive use of land in semi-primitive areas or open such areas to recreation use because of the improved access and other factors. Land values adjacent to reservoirs increase in value. The more intensive competition for water-front lands can cause a host of adverse environmental conditions if allowed to develop unregulated.

Changes may occur in the habitat for wildlife and other fauna, perhaps a critical loss for some and a gain for others. Streams may be inundated or the flow characteristics may be changed. Water surface characteristics may be modified. The type of fishery may be different from that existing previously.

Flows may be depleted by diversions or by water consumption for a wide variety of purposes. Water quality may be degraded because of the addition of waste materials or because of the concentrating of minerals as a result of some water being consumed (evaporated or transpired).

Sediment in the water may be reduced because of better land use or retention within a reservoir. Similarly, sediment loads may be increased because of greater return flows or effects on the land surface.

Water development may adversely affect scenic resources by covering scenically significant valleys or canyons or by modifying streamflow characteristics. Projects also may increase scenic values by inserting water surfaces or flows into areas where they can add to existing values. Water developments, by providing access and by providing a new resource which attracts people, can adversely affect wild or wilderness areas by permitting population pressures on fragile ecosystems. On the other hand, the development may permit the enjoyment by society of a resource previously unavailable to it.

Thus, as the Nation's population grows (albeit at a lesser rate than in the recent past), pressures will increase on the water resources of all areas. Pressures may be particularly acute in the Rocky Mountain Region and will likely affect semi-primitive areas where no particular use is precluded and where use configurations have not become rigid as with wilderness preserves or metropolitan areas. Adverse effects upon the environment will be avoided or minimized only if there is much greater understanding of environmental and ecological relationships and this understanding gets incorporated more skillfully in planning and management processes. Nevertheless, environmental and ecological adjustments for various other uses can take place. For example, tapping the latent energy resources of the region to alleviate perceived shortages will be done at some environmental cost. The challenge will be to maintain a balance which most fully serves the identified objectives of society.

Perspective on River Basin Management

Control and conservation of the region's water resources to serve man's needs and desires has been one of the major thrusts of State and Federal activity for many years. Now, however, society is indicating interest in and concern for a wider range of activities involving water so that the approach to handling the region's water resources is becoming much more complex. It is becoming necessary to view water from a basin-wide perspective which takes account of the entire river system and of opportunities for use and reuse of the resource to serve all of the different, and often competing types of uses. At the same time, management of the water resource must be coordinated with land use for recreation, irrigation, industrial development, future urban growth, and other purposes.

In the Rocky Mountain Region, the need for basin management, possibly even interbasin management, is becoming particularly acute in connection with the recovery

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and use of the region's mineral resources. The limited water supply, if it is to satisfy the demands placed upon it, must be husbanded very carefully and protected from pollution.

How effective basin management is to be accomplished must be the subject of continuing study. Skilled researchers

and managers must undertake to ascertain how this can best be accomplished. Plans for basin management on a multi-state regional basis may prove to be desirable. Later sections of this report attempt to explore many of the activities which would be involved in such management plans.

EXPANDING USES AND CHANGING PREFERENCES

The basic difficulties of water supply and wastewater disposal continue to present major water management problems. This is so particularly because they are set in a context of expanding patterns of residential, industrial, and recreational activities taking place under widely varying conditions of demography, topography, geology, soil type, slope, and elevation in the Rocky Mountain Region. Certain of these problems are intensifying as the result of events and responses in the energy arena. Others are becoming more acute as the result of major land use conflicts where environmental protection objectives are incompatible with production and development objectives. Major resource opportunities reflect themselves in major water problems.

Water and Energy

The nationwide energy crisis affects various regions differently. The Rocky Mountain Region represents a major part of the eventual solution to the national energy shortage because it contains vast unexploited resources of energy fuels. If these energy potentials are to be realized, tremendous quantities of water will have to be provided for the planned transports of coal slurry, the mining and processing of oil shale, the cooling of thermal power plants, the liquefaction and gasification of coal, the restoration of disturbed land surfaces, and the increased domestic needs associated with the towns and cities affected by the development.

Also, the control or elimination of the waste elements introduced into the waters of the region will present formidable problems. The supplying of water and the control of water pollution become matters of interstate concern in many instances. For the Colorado River Basin there are considerations of an international nature as well.

If substantial energy-related development takes place in the Rocky Mountain Region, there will be some hard social choices about water allocation and water quality maintenance. For example, it is estimated that a one-million-barrel-per-day oil shale industry would consume approximately 150,000 acre-feet of water per year. A coal gasification plant processing 24 million tons of coal per year to meet the energy needs of a million people would use about 300,000 acre-feet of water per year. A 10,000 megawatt coal-fired thermal electric power plant would consume about 150,000 acre-feet per year. (It has been estimated that thermal electric plants consume 15 acre-feet/mw, coal gasification 10 acre-feet/mw, and nuclear power 23 acre-feet/mw.)

Several mammoth coal-fired generating plants are already under construction in Arizona, New Mexico, Colorado, Utah, Montana, and Wyoming. There are prospects for many more. A whole string of coal gasification

plants is proposed within the Rocky Mountain Region. In the water-short Colorado River Basin where most of the water has been committed to other purposes, the supplies necessary to meet the potential needs of the energy-related developments being planned are simply not there. For example, it is estimated that there is a potential of 167,000 acre-feet per year in the Upper Colorado River Basin that is presently uncommitted to identified purposes. An additional 174,000 acre-feet per year, presently committed but not in advanced stages of planning, perhaps could be reallocated to energy development. Applications for water rights for shale oil development, coal gasification, and coal-fired thermal electric power generation are already far in excess of the 341,000 acre-feet thought to be reasonably available.

On the water quality side of the energy problem, the Colorado River once again presents a water problem of immense proportions. Contemplated development according to compact entitlements will result in salinity increases as a result of increased water uses. The projected increases in salinity will affect water users in the Colorado River Basin in the United States and in Mexico. It has been estimated that the harmful impacts in Arizona, California, and Nevada resulting from increased salt concentrations in the water available to them amounts to 1.7 cent/acre-foot/ppm for irrigated agriculture and 15 cents/acre-foot/ppm increase for urban users. Using forecasted use of Colorado River waters in Arizona, California, and Nevada, and the above penalty costs (over and above damages presently being experienced) gives estimated annual detriments to these states of \$14 million by 1980, \$44 million by 1990, and \$80 million by 2000.

The Water Pollution Control Act amendments of 1972 and the signing of an executive agreement (minute 242) executed through the International Boundary and Water Commission have given strong incentive to implement a basin-wide program of salinity control. This has culminated in the recent Federal enactment of a Colorado River Salinity Control measure which provides for removal of 400,000 tons of salt per year from the river system commencing by 1977, and a desalting plant near the Mexican border to guarantee salinity levels will not exceed 1010 ppm at Morelos Dam.

Thus, the sensitivity to quality deterioration in waters of the Rocky Mountain Region is vividly apparent. The mining of the richest oil shale deposits in the Piceance Creek Basin will supposedly require the dewatering of a large underground water dome estimated to contain some 25 million acre-feet. This water is highly saline and could not be released directly into the Colorado River system. The impacts of energy and mineral development on the quantity and quality of water supplies which serve a myriad of other purposes will be extremely important to understand.

Water and Environment

Of increasing concern in the Rocky Mountain Region is the rapid buildup of summer homes and resorts with more intensified use of lands along watercourses, lakes, and reservoirs. Heavy increase in recreational activities are dispersing people into the most remote areas of the Region's forests and parks. The normally high quality streams are receiving increasing loads of pollutants. Increases in coliform counts have been measured in many canyon streams. While the intestinal bacteria are normally fewer in waters of mountain streams, they may survive longer because of lack of predators which feed on coliforms. One of the real challenges of the Rocky Mountain Region will be to accommodate the vast opportunity for recreational use of mountains and canyons while avoiding detrimental contamination of the water which sustains the towns and cities below. A much greater research thrust will be needed in coming years to solve some of the waste disposal problems and water supply problems associated with recreational use of mountain and canyon lands.

The Rocky Mountain Region contains a variety of lakes and reservoirs which provide truly outstanding opportunities for recreational and esthetic enjoyment. The attraction of these water bodies is creating significant social and environmental impacts requiring careful analysis and evaluation to avoid or minimize undesirable situations. The impacts stemming from the creation or existence of these lakes and reservoirs; the chemical and biological processes occurring in the water bodies themselves; and the impacts accruing to the lakes as a result of upstream agricultural, mining, industrial, and recreational developments must be understood if region-wide potentials are achieved. Predicting responses of lake and reservoir ecosystems to various changes in water quality resulting from specific physical perturbances of the surrounding environment is the ultimate need. Such predictive models await better understanding of the structure and function of aquatic organism-interrelationships as well as the biological effects of various toxicants in different ecosystem settings.

Water and Recreation

Outdoor recreation provides one of the most important uses of leisure time for the American People and nearly one-half of this country's population participates in some form of water-based recreation. In the past, the main uses of our natural resources including water were of a consumptive nature, but we now have reached the point where we

have much competition between consumptive and non-consumptive uses. In addition, major changes in the attitudes and opinions of the public will require re-ordering of priorities and decision-making policies. Non-consumptive uses will need to be weighed against consumptive uses or preservation weighed against use.

The establishment of the National Environmental Policy Act of 1969 (Public Law 91-190) is a declaration of federal policy that "...will encourage productive and enjoyable harmony between man and his environment." This act requires an Environmental Impact Statement to be filed whenever public lands are to be altered in any form. The law allows trade-offs to be compared and public opinion and preference to be considered in making decisions regarding our natural resources. It forces federal agencies to evaluate alternatives that will minimize alterations to our environment while allowing continued growth of our country. Economic growth and environmental priorities can be compatible if the social and environmental needs of the people are balanced with the environment.

Future planning will need to be on a watershed rather than a local basis. Because of increases in leisure time, a higher standard of living, and better means of transportation, outdoor recreation is expected to continue to expand rapidly. Public demands to use water for recreation in addition to consumptive uses will place pressures on our local, state, and national governments.

For example, the Intermountain West contains numerous streams that provide recreation in the form of river running. More major river-running companies are headquartered in this region because of our water resources. Rivers such as the Colorado, Green, Yampa, San Rafael, Snake, and Salmon Rivers are some of the streams in this region that provide this unique experience. In addition, the Intermountain Region has the highest percentage of fishermen per population in the United States. Tourism is important to the economy of this Region and the water resources are often the focal point for tourists. Although this Region contains much semi-arid to arid land, the quantity of water is not as important a problem as the lack of usable water at the time and place that it is needed. Large basin transfers of water will bring about more intensive and complete use of surface streams to make water supplies available for consumptive uses in other locations within the Region. However, careful and wise management will have to be made so that demands by both recreation and development can be realized, particularly in cases where changes in our aquatic environments may be irreversible.

INSTITUTIONAL ARRANGEMENTS

Institutional arrangements have a critical impact upon the allocation and use of water in the west. In the early period of water development, loosely organized associations and cooperatives were commonly used to get canals and small projects in operation. Later public corporations were used to facilitate water development. More recent periods of water development have been characterized by Federal participation which in turn has fostered attendant organizations to promote and finance projects.

There are many indications that the policy-making process in water resources is undergoing dramatic change. While at one time the development of water resources was seen as a useful Federal investment in a relatively undeveloped West, today many see it as an imposition of national decisions upon a region where there is some debate about the benefits of development. A number of participants have gained strength and influence in the policy-making process, and there are some new participants. State agencies for planning water resources have begun to assert an independent position vis-a-vis Federal agencies. Environmental groups, once small and concerned with preservation of particular areas of high scenic value, are now asserting the right to participate in water allocation decisions. There is a growing concern about relating water resource planning to land use planning and water quality planning. It is in this area of changing policy decision making that research is needed.

The states have taken progressively more active roles in water resources planning in recent years. In the process they have had to face a number of important questions. Do state water planning agencies have the organizational capability to prepare state water plans? Are there sufficient interdisciplinary skills on state planning staffs to reflect environmental and social concerns? What are the provisions for public participation in state water planning? How do water resource planning agencies relate to water quality

agencies and to the land use planning agencies being set up in many states? How does the institutional structure of mutual irrigation companies, irrigation districts, municipal water companies, private water companies, special improvement districts, metropolitan water districts, water conservancy districts, and subconservancy districts effect state and regional planning?

Particularly in a water-scarce region, it is not possible to make decisions and manage water on the basis of state geographic jurisdiction. Allocation and use of water in one state is bound to affect other states. What are the existing institutional arrangements for interstate river basin management and what are the possibilities and disabilities of such institutions?

In the future there are likely to be strong pressures for reallocation of water. Who will make the decisions about reallocation and to what extent will decision-making authority be exercised within the Region? Do the existing institutional arrangements provide adequately for the generation of information about the social and environmental consequences of reallocation? Some decisions, especially those related to energy production, have generally been made by private institutions or organizations based outside the Region. To what extent is it possible for regional, state, and local organizations to exercise influence over energy related, water consumptive decisions?

Water quality problems are likely to become increasingly severe in the future for the Rocky Mountain Region. Salinity is already an especially bothersome water problem and has affected U.S. relations with Mexico. What are the institutional barriers and incentives to the adoption of management techniques that might extend the utility of water? What are the institutional restraints upon recycling and reuse of water?

AUGMENTATION AND IMPROVED WATER USES STATE-OF-THE-ART

How to organize and categorize elements of what should be a comprehensive discussion on water resources and uses always causes some consternation. Discussion might be organized according to water use options and the problems peculiar to each use, by components in the basic hydrologic (physical) system and the superposed non-physical (economic-institutional-social) systems, by geographic regions, by management measures, etc. For no overwhelming reason except perhaps to facilitate dividing up the task, the task force chose to categorize topics according to major management measures which are (or may become) prominent in water problems related to allocation of a scarce resource. Such measures have the effect of augmenting water quantities and preserving or enhancing utility of existing supplies to satisfy a greater number of legitimate uses.

In the following sections the "state-of-the-art" of the management measure is treated along with some significant related considerations in the implementation.

Watershed Management

Watershed management is essentially the management of land for the conservation and production of renewable (and non-renewable) natural resources. It is concerned with relationships between the management of soil and vegetation and the quantity, quality, and timing of water production from watersheds as they affect both on-site and downstream use. Watershed management involves prescribing some kind of land use, non-use, or modification of vegetation cover to meet prescribed needs. Its objectives such as the production of timber, forage and wildlife, and the protection or enhancement of scenic values and recreation environments are inextricably linked with water.

Many land management practices designed to affect hydrologic regimes of watersheds can be placed in two general categories (1) the protection and rehabilitation of soil and plant resources, and (2) the management of watershed resources to modify the quantity and/or timing of water production.

Watershed protection is concerned with the development and use of practices that will maintain the productive capacity of soil and preserve the quality of water flows yielded by watersheds. Rehabilitation may be required for watersheds that have been disturbed or damaged by wildlife, excessive grazing, improper timber harvesting practices, mining activities, and other natural or man-related agents. Rehabilitation may include seeding with range grasses, forbs, and shrubs; reforestation; controlled or managed grazing; use of structures; shaping and productive distribution of mine wastes; periodic use of prescribed fire to

reduce fuel buildups that may lead to disastrous wildfires; and the application of other cultural practices.

Land management practices designed to affect the quantity and timing of water flow from watersheds often involve some modification of the vegetation cover. Practices which reduce the density or dominance of heavy vegetation cover tend to reduce evapotranspiration depletions and thus increase water yields; and practices which favor the development or maintenance of heavy vegetation cover tend to bring about increased water losses through evapotranspiration and thus decrease or minimize water yields. In short, practices which reduce rates of evapotranspiration and transpiration on watersheds tend to increase water yields. While imperfect, present knowledge can be used to make qualitative judgments about changes in streamflow that may result from management activities such as timber harvesting.

Economic Considerations

Since watershed lands in the Rocky Mountain West are primarily in public ownership, and since water supplies transitorily in contact with these watershed serve a myriad of purposes elsewhere, assessment of watershed management practices on any specific watershed must not be made in isolation of the subsequent uses of water at downstream points. Water concerns for production of timber, forage, wildlife, fisheries, and mineral and energy resources, preservation or enhancement of scenic values; and the development of recreation opportunities are not restricted to the location where the water originates as precipitation. As has been pointed out previously, these legitimate water uses are often in competition. For example, practices that maximize water yield over the long run may minimize timber production and increase sediment yield. However, other products and values may have complementary relationships in which increased production of one is accompanied by increased production or value enhancement of another. Thus, economic evaluation of watershed treatments on public lands involve many complex and interrelated tangible and intangible factors.

Environmental Considerations

The use and management of natural resources on watersheds can affect the environment in both obvious and subtle ways. Timber harvesting practices may cause unsightly landscapes in the opinion of some observers due to slash piles, roads, and perhaps unnatural-appearing borders around clear-cut areas. Strip mining may also damage the appearance of a landscape. The removal of riparian vegetation for flood control or water salvage objectives could change certain wildlife habitats. Heavily grazed land

may show signs of erosion and may cause sedimentation downstream. The improper use of herbicides can have undesirable effects. Smoke from prescribed fires may cause air pollution. The nutrient content of streamflow may be altered as a result of some vegetation management practices.

These and many other examples help explain the increased concerns which have been expressed by the public about the environmental impact of some land management practices. As a result of these concerns, the extractive industries, land management agencies, universities, and others are intensifying efforts to devise means for utilizing natural resources on watersheds for their tremendous economic benefit without causing unacceptable changes in the environment.

Legal and Related Considerations

Many watershed treatment programs have been opposed by environmental action groups. For example, riparian zone clearing operations have recently been terminated in Arizona on the Gila River. The use of certain herbicides has been suspended by government agencies, often as a result of opposition by environmental action groups. Herbicides were widely used to reduce or eliminate unwanted plant species in order to encourage those species having greater economic usefulness. The suspended use of herbicides has had an important effect on many land management programs.

The requirement for preparation of environmental impact statements on major Federal or federally-funded projects has caused much change in the operational procedures of government agencies, and scheduled projects have been delayed as a result. Some projects have been improved in the process, however.

There are some interesting but unresolved legal questions associated with vegetative manipulation to increase water yields. Water developed by any means can become the property of the person making the development. If the amount of water salvaged by phreatophyte control, snow management, or other means can be identified as new water in a river system, then it can be claimed. (This may not be a simple matter, however.) Questions also arise with regard to changes in watershed management which result in a decrease in streamflow. How do you compensate water-right holders for a loss of water supply caused by upstream changes in watershed management practices?

The institutional aspects of watershed management relate to who the managers are and how they make management decisions. Watersheds in western states have a whole roster of managers at various levels of government. Looking only at the management agencies on the Federal level -- Bureau of Land Management, Forest Service, Park Service, Soil Conservation Service, Bureau of Reclamation, and Army

Corps of Engineers -- the list is impressive. These agencies tend to have their own organizational doctrines and favored management practices. At times management is confusing and contradictory. Further, different agencies have different procedures for public participation.

Treatment of Sewage and Reuse of Effluents

Increasing summer and winter recreational uses of mountain lands is creating waste disposal problems with subsequent hazard to water supplies below. Shallow soils and fractured bedrock tend to limit the natural filtering action of soils and make conventional waste treatment questionable. If recreational and tourist potentials are to be realized, the characteristics of waste disposal on mountain lands must be assessed and economical ways devised to treat and manage them so that land and water use potentials from headwater regions to valleys below will not be curtailed. It is important to learn whether or not conventional waste treatment will be adequate for homes and resorts, but equally important is learning how to cope with wastes being deposited in a diffuse way over our watersheds.

As a general observation, there is a considerable amount of technology available for wastewater treatment in common use or developed sufficiently for immediate application to sewage treatment and treatment of effluents for removal of suspended solids and for oxygen-demanding materials. Present and future treatment of water for reuse will require more advanced treatment in reducing dissolved solids, nutrients, toxic materials, and for complete disinfection. Application of available technology is limited by economic as well as technological considerations.

Forest and mountain areas have particularly acute problems with respect to handling of wastes. Recycling of treated campground and recreational facility wastewater through forest and cropland may be an effective way of solving waste problems in certain situations. Land disposal may be utilized in designs which may enhance rather than degrade environment. The chemical and biological quality of treated effluents and sludge, the fundamental functions of soil and its associated biosphere, qualitative changes in wastewater during recycling and responses to soil vegetation, and wildlife would all have to be considered. The experience of such land disposal methods in various parts of the country would be helpful in assuring the adaptability to specific Rocky Mountain Region applications.

Man-made lakes are becoming more numerous in connection with certain recreational and permanent home developments. While such water features add greatly to the beauty of the residential setting, to maximize lake fronts properly such lakes are often planned with sinuous shorelines or fingers. Special precautions must be made to maintain circulation and prevent high potentials for

developing eutrophic conditions. Special care and attention to hydrologic, hydraulic, and water quality characteristics must be given if potential environmental degradation problems are to be avoided with the construction of artificial lakes and ponds.

Secondary treatment processes reduce the amount of organic matter in sewage through bacterial action, oxidation, and synthesis. The most common methods are the trickling filter and the activated sludge processes. These processes, following primary treatment, typically remove 90 percent of suspended solids, 90 percent of biodegradable organics, 80 percent of nonbiodegradable organics, 50 percent of nitrogen, 30 percent of phosphorus, and over 99 percent of pathogenic bacteria and viruses. After secondary treatment, the following impurities usually remain in the effluent: (a) suspended and colloidal solids; (b) refractory organic matter that is resistant to biological treatment, such as pesticides, and the products of bacterial metabolism; (c) plant nutrients, principally phosphorus and nitrogen compounds; (d) dissolved mineral matter, such as sodium chloride and other mineral salts, all of which are present in an original water supply, but are usually increased by use; (e) bacteria and viruses, some of them pathogenic.

There has been no process yet devised which is able to remove all contaminants economically in a single step. Several desalting processes remove all pollutants except some of the pathogenic organisms, but these processes are not promising economically for wastewater treatment. Instead, the method considered most desirable is a series of individual processes, each successively removing one group of impurities in a single step.

Application of newer processes of wastewater treatment as individual unit operations and combinations of sequence units for economical and reliable operations must be proven by reduced size modeling and testing. Combination units capable of handling multiple-treatment functions are needed now for more economical treatment operations.

In addition to conventional physical and biological treatment, efforts are needed to demonstrate the future benefits of treatment processes such as ion exchange, reverse osmosis, and adsorption.

Reductions of nutrients in wastewater for retarding biostimulation and methods of sludge treatment to recycle nutrients should be thoroughly investigated for each type of wastewater treatment.

Social and Economic Considerations

There appears to be considerable antipathy by public officials toward the reuse of effluent from wastewater treatment plants. Although it is not clear that the general public has always been made aware of the alternatives, it

has responded to the call of public officials by agreeing to pay more for so-called "pure" natural supplies. New York City, for instance, has consistently chosen more costly supplies from the Catskills, even though plentiful resources are available in the Hudson River which could have been made potable at less cost.

The future of reuse for general municipal supply is dependent upon two factors: economics and public acceptance. To date, alternative sources of supply have been more economical than the supply made available by advanced treatment. Therefore, there has been no demand for reuse for general supply. It is probable that such demand will build up gradually and in selected locations of water scarcity. When it does, public acceptance probably will follow without too much difficulty, provided health officials become convinced there is no virological hazard. However, until there is a clear economic advantage to reuse for potable supply, it is probable that public acceptance and approval will be slow.

Alternatives exist between ways of financing first cost of treatment units and continuing operating and maintenance costs. If combined treatment facilities for both municipal and industrial wastes are to be considered, equitable participant charges for operating and maintenance costs must be developed.

Methods of evaluating net treatment costs involved in reuse systems are needed which take into account the costs of equivalent supply from other sources. The returns (benefits) from wastewater treatment for reuse are researchable areas of concern.

Legal and Institutional Considerations

Legal problems of reuse of effluents are similar to those for evaporation and seepage control. Water rights may have been established which are dependent upon the effluent, and such rights may affect the extent to which the effluent can be used for a new purpose.

The setting of water quality standards is an extremely critical factor in the use of water. While the objective is to maintain quality for a wider variety of uses and health and esthetics, achieving those standards in mountain watersheds could be a major problem. Particularly in headwater areas where skiing, backpacking, hiking, fishing, etc. may be most appealing, if proposed standards insist on zero pollutants, uses may have to be seriously restricted, or expensive and unbecoming facilities may have to be provided to collect and haul or pipe the waste to treatment plants considerable distances away.

Institutional problems of water pollution control are exceedingly complex. Water quality has historically been the concern of state government. Increasingly, especially under

the water quality amendments of 1972, the Federal Government has assumed regulatory and funding roles. The intergovernmental relations in the field of water quality are changing and not yet fully defined.

Environmental Considerations

Forest and mountain areas have particularly acute problems with respect to handling of wastes. The heavy influx of recreationists and recreation vehicles, together with construction of more summer homes and resorts on watersheds from which domestic water supplies are derived, cause considerable concern. It is important to learn whether or not conventional waste treatment will be adequate for homes and resorts. Effluents thus generated may enter surface and groundwater supplies directly and thus constitute a "reuse." Site conditions suitable for conventional septic waste disposal need to be evaluated with respect to potential pollution.

Irrigation Water Management

Present Status

In the West, irrigation is easily the largest consumptive user of water. Improving the management of irrigation water both in the distribution system and on the farm can have a significant effect upon the semi-primitive areas either by reducing demand on upstream areas or by permitting increased uses for other purposes upstream.

The term irrigation water management can encompass a wide range of measures to increase the efficiency with which water is being used. It can include improvements to the irrigation distribution system to reduce canal and lateral seepage, use of a demand system to improve water scheduling and reduce wastage, measuring devices and water charges graduated upward to encourage water use efficiency, and similar measures. It can also include on-farm measures to improve the efficiency of water use on the farm. Measures can extend from improved land preparation, lined farm ditches, and effective water diversion structures, to a whole range of new technologies -- automated water application systems, automated water supply systems, and moisture sensing and computerized water application scheduling. Recent research suggests that irrigation efficiencies of as high as 95 percent or more combined with very precise irrigation applications tailored to the crop's daily needs may be effective in reducing the salinity in the irrigation return flows. However, such claims must be viewed with caution because they may represent short-term reductions which must be balanced out in the long run.

Over the years a great deal of research has been done by the universities and the Federal Government to improve on-farm water application effectiveness, and relatively a great deal is known about the means of managing individual irrigation

supplies. In areas where water is scarce or high priced, much of what is known is being applied, even to the point that in a very few instances crops are being grown in controlled environments. In other areas where conditions are different, irrigation has changed little in the last 50 years. Similarly, much is known about the means to increase the effectiveness of irrigation distribution systems; application of this knowledge tends to increase as water becomes less plentiful or more costly to the water-using entity.

Economic Considerations

In the Rocky Mountain Region it appears that the greater irrigation efficiencies tend to occur in the southern area where water is scarce and expensive and where a rather wide diversity of crops can be grown. In some areas in the southern and many areas in the central and northern parts of the region, improved management of irrigation water is taking place very slowly, particularly in the older irrigated areas.

Economic factors appear to have been decisive in determining the extent of the individual's or the distributing entity's efforts to improve water management or to adopt new techniques. The individual water user will upgrade his management only when he recognizes some advantage from doing so. He must see the opportunity to increase production enough to more than offset the increased costs, or he must recognize that the cost or scarcity of water makes it financially necessary or attractive. No doubt as water in the West becomes more and more in demand and thus scarcer so far as the individual is concerned, improved technology will be adopted more rapidly.

Study needs to be given to the environmental effects of possible management measures. Moreover, there needs to be an exploration and reexamination of forms of incentive which can be used to encourage individual actions consistent with environmental protection. Once again, it could be emphasized that, because of return flow phenomena what is considered good management at the individual level does not automatically aggregate to best regional management of the water resource.

Environmental Considerations

Because of the large quantities of water required and the massive engineering works to provide the necessary storage, conveyance, and distribution, irrigation development entails substantial environmental trade-offs. While the negative effects are often more emphasized, there are, of course, some very significant positive environmental impacts. Under regulated flow conditions river boating seasons are extended, channel profiles are stabilized, new (albeit different) fishing habitat is created, and recreation opportunities for broader segments of society are provided. On the other hand, the inundation of certain valuable lands and landscape, the superposing of physical works and the disturbance of natural

landscapes, and the altering of certain biological systems are environmental costs. Examples of environmental trade-offs have been cited in earlier sections.

The seemingly proper action of an individual, with respect to the use and management of his water, is not necessarily the proper action with respect to environmental protection. This appears to be one of the major causes of environmental deterioration and of the inability of our system to function in a manner that will prevent such deterioration. The individual who drains his marshland is making the proper decision from his viewpoint since he has the cost of taxes, interest on investment, and profit foregone unless he makes the improvements. However, society at large may feel a loss in terms of waterfowl or wildlife as a result of the drained marshland.

Legal Considerations

The water laws of all Rocky Mountain States are based on the principle of reasonable beneficial use. The water right holder is generally protected if his method of use is consistent with local custom and not grossly contrary to the public interest. Recent water quality legislation has given reason to more closely examine water right doctrines relative to wastewater management and irrigation efficiency. The National Pollutant Discharge Elimination System permit program and "no pollutant discharge" goal give rise to the need for study of the legal implications of the NPDES law, and rules and regulations upon state-granted and court-adjudicated water rights.

River System Management

Present Status

In the Rocky Mountain Region the rivers already serve a wide variety of purposes, both those involving diversions from the river for uses such as irrigation or municipal water supply, and for in-stream uses such as canoeing or fishing. These diverse and often conflicting uses have developed over time through the actions of different groups and individuals. In general, and in spite of many statements to the contrary, most approaches to river system management have included only one or at most a few of the many purposes for which water is being used. This is understandable in many instances since specific uses and their value to society change substantially with time and circumstance. Consequently, other existing or potential uses are not properly recognized and provided for in terms of present social preferences.

In view of these conditions, it is becoming increasingly necessary that rivers be managed as a system in which there is a dynamic balancing insofar as possible of all of the diverse types of interest in the stream. There needs to be a concerted effort to extend the utility of the limited resource so that it will satisfy most fully the various needs and desires of society for

water. The effort would include managing the system for improving recreation opportunities, for improving water quality, for improving its availability both as to time and location, and for restoring some reaches to nearly virgin conditions.

Since this kind of systems approach to managing river basins has not yet been fully developed, a great deal of attention must be given to the formulation of techniques and appropriate institutional arrangements. A major management tool would be reliable predictive models for evaluating the effects of changes in management practices. Such models would facilitate analyses of such things as changes in water quality resulting from alternative corrective measures.

Economic Considerations

While much of the basic regulation required has been provided on most rivers to allow a wide range of uses, often little if any provision has been made for many of the potential upstream uses. While in part this has been due to the fact that the uses were competitive, and the instream use advocates had no way of "bidding" when water was allocated to those contracting to repay development costs, more often it has been because the developers were limited in their scope of interest and because there was no provision for financing the costs of protecting instream uses.

Developing and operating the river system management program also will require funds, as will management tools such as predictive models. Presumably the beneficiaries of the system operation should pay the costs. However, a large proportion of the users are not organized, in fact may not even live in the basin, and in the past have not considered that they were obligated to pay for the services they received.

An important area of study is that of the means for financing sound and adequately funded management activities.

Environmental Considerations

Possibly the greatest opportunity for environmental improvement, as related to water, is in improved system management. Under such a program water uses could be balanced against their effects on water quality, and the system could be managed to minimize the adverse effects. Ecological effects would be analyzed on a continuing basis, and again, the system would be managed in such a way as to reduce those effects wherever possible. Sequential water uses would be built into the system so that water used for any purpose would be consistent with the quality required for that use.

While a number of years would be required on any river system to develop and adapt existing uses to such a system, it could in the long run be one of the most important in terms of

permitting environmentally sound decisions in the semi-primitive areas. However, extensive and difficult analyses and negotiations will be needed to reach this goal.

Legal Considerations

Our water laws and related institutions have been developed to protect the individual or group water-right holder, to the extent that his actions are within what is conceived to be the public interest. By and large they have not been used to protect all of the diverse interests in water, although the trend certainly is toward a much more balanced approach to water administration. The districts and other organizations developed to build and operate water systems have felt a responsibility largely only to the specific functions for which the works were built and the users of water for those purposes. The same holds true for the individual. He is interested in using the water for the purposes for which he obtained it and for his personal benefit.

Finally it must be recognized that historically, some Rocky Mountain States have water laws that consider surface water and groundwater as separate and distinct water sources. Appropriations from one source were made and water use was managed without regard to the interrelationships of the two. The National Water Commission report correctly points this out as a major administrative problem and recommends state legislation to provide the mechanism for integrated management. Studies should be made to develop model state legislation providing for management of the entire resource and for creation of legal entities with authority to provide needed water supplies by substituting water from surface water or groundwater as needed.

Interbasin Water Transfers

Present Status

In the Rocky Mountain Region use of water for a wide variety of purposes has been extended to the point that a number of the major rivers are at or approaching maximum use of the resource in some reaches. This would apply to such streams as the Platte, the Powder, the Colorado, and the Rio Grande. Because it is, perhaps the most fully utilized, the Colorado River offers the best example of the problems to be encountered in the region as economic growth and water demands increase. Problems of competing uses have become more intense. The salt-concentrating effect of water consumption and the salt-loading effect of return flows have led to an increasing salinity. Finally there is recognition that soon new consumptive uses will be possible only if other existing consumptive uses are curtailed or if there is an augmentation of the Colorado River supply.

The appreciation of impending greater difficulties in the region has led to continuing discussions of possible transfers of water from other river basins, even of international transfers.

Interbasin transfers of water, of course, are not new; numerous transfers, both small and moderately large, have been made in the Rocky Mountain Region and others are in prospect. The existing transfers from the Colorado River system to Denver and other eastern slope areas of Colorado are examples of the more important transfers. Possible major transfers to augment the Colorado and other regional streams, however, have not been studied in any depth as yet. In fact, at present Congress has placed a moratorium on studying one of the more commonly discussed possibilities.

While the objectives and principles involved in water development are independent of scale, experience with existing smaller-scale development does not necessarily provide all the answers to such large-scale development. Elements of the planning matrix can relate in much more subtle and devious ways and combine to create much larger impacts. Such large scale redistributions of water have potential for major and sustained impact on both the exporting and importing areas.

The technology of water transfers is quite well understood insofar as the physical works for the transfer are concerned, assuming that such a transfer would be conventional. That is, that it would involve canals, pumping plants, generating facilities, and so forth. These types of works are well understood and can be built successfully to any reasonable capacity.

The same physical, legal, economic, environmental, and social tests used to evaluate the feasibility of permitting almost any kind of diversion should apply in principle to any large water transfer scheme. Obviously, there are complications should a transfer involve multiple states or sovereign nations. All of the economic, ecologic, recreational, institutional, legal, political, and social impacts in both the area of origin and the area of import would have to be carefully assessed and the trade-offs understood. As has been stated earlier there are no "surplus" waters that can merely be transferred from non-use into use.

Economic Considerations

Both construction and operating costs of interbasin transfer works would be high. Also, the adverse economic effects in the basin of origin would have to be considered. However, while there has been a great deal of discussion regarding these effects, there have been no reliable studies to ascertain what they would amount to. Nor have there been reliable studies of what favorable or unfavorable effects will occur in the receiving areas nor of their value. Presumably, before any such transfers can be accomplished, it will be necessary to demonstrate that existing water supplies in the receiving area are being used efficiently, that the transfer is the cheapest means of obtaining the demanded supply, that adequate protection is given from the imputed social, economic, and environmental costs to source area, and that

the transfer represents an efficient use of the Nation's natural and financial resources.

Because of the size and complexity of such transfer systems, a great deal of study and research will be needed to make the necessary evaluations and analyses.

Environmental Considerations

Much less well understood than the technology of water transfers and much less well studied, are the environmental effects upon both the source and receiving basins. Construction of control and diversion works, and the removal of substantial quantities of water may have significant effects in the source area. The regimen of the stream certainly will be disturbed; removal of water will reduce stream flows at some period and may affect other uses of water and groundwater replenishment. It may also preclude other possible future uses of the same water. It also, of course, may have no adverse effects.

Similarly, the introduction of a quantity of water into a basin would change the streamflow and storage characteristics of that basin. The increased flows may improve water quality, improve the fishery, provide greater recreational opportunities, or strengthen the industrial and economic base of a region. The effects, whether environmental or social in character, are very site-specific and usually are subject to modification or control according to particular planning alternatives.

Legal and Institutional Considerations

"Intrastate" water importation has been practiced in many areas of the Rocky Mountain States under provisions of state water laws for many years. Although conflicts have arisen between the area of origin and the areas receiving the water, once the water rights and political decisions are made, the projects proceed. There are few legal constraints. Interbasin transfers between states which are in whole or in part in the same basin are another matter. Such transfers are usually controlled by the powers of Congress and by interstate compacts. There have been no interbasin transfers of water between states which were not at least in part within the same basin, although presumably Congress can authorize such transfers if and when it chooses to do so. There are some, however, who feel that the power of Congress over state-claimed water still is uncertain.

Further study needs to be made of methods of protecting areas of origin of imported waters, both as to water supplies for further uses and compensation for losses. Authorizations could provide for such controls or actions as might be necessary to make the transfer conform to desirable land use plans and environmental protection. The difficulty has been that the effects have not been studied adequately in advance of development so that proper provisions for protection of the environment have not been identified and included in

the plans. Similarly, there seldom is a sound and well conceived land use plan with which a particular development must comply. These are deficiencies of our planning programs, governmental organization, and administrative regulations.

The institutional problems related to interbasin transfers were thoroughly discussed by the National Water Commission. Of particular concern was the political power of areas of origin to protect their interests and receive compensation in a situation where Congress is asked to authorize and fund a large-scale water transfer. The Commission suggested that Congress apply strict economic criteria in decision making on interbasin transfers. The Commission found that the institutional arrangements, where Federal agencies that built projects also evaluate them, were unsatisfactory.

Flood Control

State-of-the-Art

The term flood control as used in this paper, refers to a number of measures designed to prevent or reduce the damages resulting from snow melt or storm water runoff. The term encompasses the control of floods, by levees, storage works, channelization, or flood plain management.

The most common means of flood control are by levees to confine floods within fixed limits and reservoirs to contain the flood flows until they can be released without damage. Channelization is designed to permit greater flows to pass through an existing stream bed without overflowing its banks. It includes such activities as cleaning, straightening, deepening, or otherwise modifying the existing channel. Flood plain management involves controlling land use in the flood plain in such a way that high flows can be accommodated without extensive damage to property in the flood plain. In spite of its seeming advantages, flood plain management has been least successful to this time as a means of preventing damage.

Techniques for the physical design and construction of levees and dams are well advanced and carried out with assurance that the works will perform satisfactorily their primary purpose. Stream channelization procedures can be undertaken with a lesser degree of assurance that the resulting channel will be effective in controlling floods. Each of these procedures, however, can have a serious environmental or ecological effect. While great strides have been made in recent years toward an appreciation of these effects and toward measures that will reduce them, further work must be done.

Flood plain management usually will not involve construction or significant changes in land use in order to be effective. Rather it requires an understanding of conditions in the flood plain and a plan for handling floods within the flow limitations of that flood plain. In some cases, storage

may be needed in connection with flood plain management. The difficulty with flood plain management is that the lands in the flood plain often have the potential for much more intensive agricultural or even for urban purposes. There is an understandable reluctance on the part of the land owners, as well as, quite often, local governmental officials, to accepting limitations on the use of these lands. However, in many cases, with proper planning such lands can be used intensively. Where such use is not possible, of course, the lands should be acquired and converted to some form of public use.

A problem with the flood control program is that means to control land so as to retain for society the option to choose the most desirable means of preventing flood damage in any instance are limited. Where intensive use of the flood plain land is permitted to take place, flood plain management is no longer a viable option. Searching for means to make flood plain management effective as an option in preventing flood damage is an important endeavor. There are land-use controls which mitigate flood losses, but research is needed to foster the implementation of these non-structural techniques of rational flood management.

Economic Considerations

Flood control projects are expensive. Yet the damages, discomfort, and sometimes loss of life from flood may far outweigh the financial cost of providing flood control works. However, all costs must be taken into account, including those of a social or environmental nature. Failure to do so can lead to errors in project formulation. It is equally important that each alternative means of damage prevention be analyzed fully and reliably, particularly with respect to the ecological and environmental factors.

Social and Institutional Considerations

A major flood may cause havoc in a built-up urban area. It can result in social effects of extraordinary magnitude although inexpressible in monetary terms. At the same time, flood control projects, by providing a degree of flood protection, may encourage uses of the flood plain which can result in very great damages if the works fail. These could include such uses as summer or recreation homes located in the flood plain below flood control reservoirs.

Traditionally, institutional factors such as the limited missions of Federal construction agencies and the desire of local governments to build a tax base even if it meant building on the flood plain discouraged flood plain planning. Currently Federal agencies such as the Army Corps of Engineers and the Water Resources Council are displaying far greater concern for non-structural solutions to water problems.

Environmental Considerations

Flood control projects may have significant environmental effects. Reservoirs, of course, remove some land from other uses and may remove a stretch of open stream and some habitat for wildlife. Levees or channelization may result in loss of wildlife habitat or cause other significant ecological effects during the construction process by destroying or isolating some areas. Flood control works may directly or indirectly influence land uses such as encouraging settlements in the flood plain below reservoirs or behind levees in areas that otherwise would have remained in a semi-primitive condition. Important scenic values may be lost even when great care is taken.

Legal Considerations

Flood plain management as an alternative to construction of dams and levees must be given consideration. Few states have adopted state laws in this area and many communities with flood hazards have not qualified for the National Flood Insurance Program. Incentives embodied in legislation recently enacted by Congress have added emphasis to the need for local and state government to act in this area. Further study should be made of means of guiding (or prohibiting) development of flood-hazard lands.

Cloud Seeding for Water Supply Augmentation

Assessment

The processes of cloud seeding are insufficiently understood to predict all results with certainty. Statistical analysis of well-designed field experiments have indicated that ice-nuclei seeding can sometimes lead to more precipitation, can sometimes lead to less precipitation, and at other times the nuclei have no effect, depending upon the meteorological conditions. It is now possible to specify the conditions and properties of orographic cloud systems that determine their response to artificial nucleation. Other cloud systems are not as well understood.

Orographic lifting of an air mass as it approaches mountainous terrain is a well-known mechanism causing precipitation. Extensive and long-range experiments with orographic clouds have been carried out in Colorado and California. When the cloud temperature at the 500-millibar level is within a certain temperature range (supercooled), the precipitation on seeded occasions is substantially greater than on non-seeded occasions. The increase ranges consistently between 10 and 30 percent. Seeding at temperatures above or below the critical range produces inconsistent results including decreases in precipitation amounts.

Convective clouds have been seeded in numerous experiments around the world. Some have shown precipita-

tion increases under certain conditions, but the majority of trials have been inconclusive. Many trials have shown statistically significant precipitation decreases. Most encouragement has come from studies on single cumulus clouds in which seeding releases latent heat, in turn increasing cloud buoyancy, and finally causing increased precipitation (as much as 100 percent increase). The potential for significant total water supply increase by this mechanism is, however, very small (perhaps 1 percent increase over a river basin). Whether or not cloud "mergers" can be effected by this process in such a way that the areal precipitation increase would be significant remains to be learned.

Convective cloud seeding is in its infancy. The system is far more complex than orographic systems. The parameters which control cloud response to artificial nucleation have yet to be established before the process can be considered operational.

Relatively little research has been conducted to learn if the amount of precipitation from storms that are neither orographic or convective can be altered by means of cloud seeding. Much more experimental evidence is needed before even tentative conclusions on seeding such storms can be reached.

The question of how much usable water is made available by cloud seeding needs to be raised. Can increases be counted on during drought periods? Does increased runoff occur and does it occur at the times when it is needed? Can long-range storage be provided to carry over increased runoff into dry years? All these questions are relevant in considering the water supply augmentation benefits from cloud seeding. Answers are not now available.

Inadvertent results of cloud seeding will play a significant role in the adoption of this technology. At this time, field data are inconclusive as to the downwind range in which seeding may be effective. Both precipitation increases and decreases have been recorded several hundred miles downwind from target areas. Other climatic changes could result from changing the regional energy balance by cloud seeding. These effects are yet poorly known and inadequately documented. However, great concern is evidenced on the part of those who perceive reduced precipitation in their area as a result of cloud seeding at a distant site. The "milking" of clouds, if it in fact occurs, could become an issue of interstate conflict. Intrastate conflicts have already occurred in several cases where cloud seeding was practiced.

Social and Economic Considerations

The determination of the social and economic consequences of modifying precipitation may be more difficult than establishing the physical parameters for the new technology. Inadvertent modification, mentioned above, constitutes one of the most serious problems because it

implies possible damages and interference with presumed rights of others. Economic consequences could be felt by great plains agriculture if only a small fractional decrease in annual precipitation were experienced due to cloud seeding outside the region. Likewise, inadvertent increases in precipitation could lead to damages because of floods, inability to harvest, crop yield reduction, and the like.

Ecological Considerations

Precipitation increases probably will result in some alteration in the structure of plant and animal communities because of changes in rates of reproduction, growth, and mortality of weather-sensitive species. It is possible that catastrophic outbreaks of insect or weed pests could occur (although this is considered unlikely). Increased snow accumulations from wintertime seeding could adversely affect wildlife by covering winter feed. The deposition of chemicals used in artificial nucleation on vegetation might pose a threat in the biological food chain. At this time relatively little factual information has been accumulated on these questions, although studies are in progress.

Public Policy Issues

Some of the policy issues that will have to be considered in developing procedures and policies for operational weather modification have been identified in recent years. Techniques of benefit-cost analysis will have to be applied to special problems encountered in cloud seeding. Possible ecological effects of operational programs must be examined in order to anticipate and minimize undesirable changes in the environment. Appropriate legal regulations and procedures will have to be developed which will facilitate research, ensure that the public interest is protected, and provide compensation for damages.

The justification for continuing to develop cloud-seeding technology can be clearly seen wherever water supplies are inadequate. Throughout the Western United States, competitive demands on limited water resources bring the augmentation potential of cloud seeding into sharp focus. Increased surface runoff can accommodate increasing demands for municipal and industrial supply that will otherwise be obtained by transfer from agricultural use. Dilution of salts in many western rivers would constitute a valuable contribution from cloud seeding.

In considering the prospects of increasing precipitation by cloud seeding, the costs and secondary impacts need to be understood. As one alternative for increasing water supplies, the technology should be developed, but other alternatives must also be considered and developed where possible. Finally, the selection of which alternatives to use at which times should depend upon a thorough understanding of all costs and consequences for each alternative. Impacts of each technology on economic, social, political, and esthetic conditions should be well established before heavy

operational commitments toward any new technology are made.

Legal and Administrative Constraints

There is currently very little legislation controlling activities in this area. The only Federal control is PL 92-205, the Weather Modification Reporting Act. This act requires non-Federal entities to report their activities to NOAA. Some states have adopted laws requiring permits to conduct cloud seeding operations. South Dakota has enacted provisions for counties to levy a one mill tax on real property for a "weather modification" fund.

Research needs to continue into the legal implications of interstate effects of cloud seeding operations. Study should also be made of the possible development of "model" state laws following the recommendations of the National Water Commission that this activity be controlled at the state and local level until such time as the processes and side effects are more thoroughly understood.

Evaporation Suppression

Technical Considerations

Evaporation losses from impoundments, particularly in the arid Western States, represent net depletions from available supplies which are very real and very large. Reducing the amounts of water lost through evaporative processes could result in the availability of more manageable water in a system. Controlling seepage losses on the other hand, merely re-routes available supplies without changing total quantities in a river basin sense.

In practice, the evaporation loss of water from shallow storages, such as stock tanks and farm ponds, often exceeds the amount utilized. According to estimates, for a 1-acre stock pond having no seepage loss and located in a 100-inch evaporation area, 125 head of cattle would consume 11.8 percent of the available water, and 88.2 percent could be lost to evaporation. Evaporation from large reservoirs results not only in a significant water loss in terms of supply, but results in an increase in the concentration of salts in the remaining water.

Methods of evaporation control that have been investigated include the use of certain alcohols, such as cetyl alcohol, which are long and slender molecules that align themselves side-by-side on a water surface to form a film that is one molecule thick. The system requires only small amounts of material (up to 0.05 pounds per acre of water surface); it does not restrict the transmission of oxygen to the water; and the materials are non-toxic to fish and humans.

Significant evaporation reduction requires an essentially continuous, undisturbed film, which has been difficult to

achieve when winds exceed 25 kilometers per hour. Using such monomolecular films on small ponds has been found to be impractical because maintaining a film cover requires that the material be applied continuously in windy conditions. Maximum evaporation suppression, even with a wind-activated dispensing system, has been 35 percent. The economics on larger ponds are better but in general the costs are greater than the benefits under present technology.

Light-colored floating materials that reflect more of the incoming solar radiation than does a water surface can be used to reduce evaporation losses significantly. Some materials such as perlite and chopped expanded polystyrene depend entirely on reflection to reduce evaporation.

Other floating materials such as concrete, polystyrene sheets, wax, rubber, and plastic sheeting, also reflect incoming radiation but primarily function as a vapor barrier. The latter types are more efficient. Concrete blocks made of lightweight aggregates have been used successfully on a 10,000 m² reservoir in South West Africa. An unusual cover that has recently been developed is floating wax. The wax is placed on the water surface. In the sunlight it softens and flows to form a film covering the surface. It is soft and flexible but not molten.

Expanded polystyrene sheets one inch thick have been coated with asphalt and gravel chips and coupled together to form a floating raft. The raft is said to be nearly 100 percent efficient since it provides both an energy and vapor barrier. The temperature of the uncovered portion of the lake does not significantly rise due to evaporation control on the covered portion. These rafts do require fencing against livestock and animals.

Foamed butyl rubber and laminated foam-butyl rubber have been used to make a continuous membrane for evaporation reduction. These materials normally come in four-foot-wide rolls and can be made to conform to any shape by splicing and cutting. The material is relatively expensive but durability is good and life expectancy is in excess of ten years. Plastic sheeting has also been used to cover reservoirs, but these attempts have been less successful than those using the foamed butyl.

Evaporation has also been controlled by storing water in reinforced butyl bags and rock-filled reservoirs. Butyl bags have been used in the Western United States for stock water supplies. Recently three small plastic-lined rock-filled tanks have been successfully built near Safford, Arizona. Commercial rock pickers were used in filling the tanks. The capacity was reduced by approximately 55-60 percent due to the rock, but the evaporation loss is reduced by approximately 90 percent.

Evaporation can also be reduced in existing areas by diking off shallow areas that contribute relatively little to the storage capacity. Other techniques include locating

proposed reservoirs at higher elevations when possible and where the ratio of surface area to total storage is lowest.

Economic Considerations

Historically the cost of evaporation control has been high compared to the value of the water saved. With the value of water increasing and the advent of newer low-cost materials, the economics of evaporation control will likely improve.

Environmental Considerations

The environmental impact of evaporation control (other than the use of the alcohol monolayer) is significant. Floating covers cannot be hidden from view. The covers are restrictive in the sense that the covered portion of the water cannot be used for other purposes such as recreation. Studies have indicated that a floating raft can cover up to one half of the surface of the lake without significantly affecting fish growth. The use of floating covers, however, would in general, be confined to use on reservoirs where water supply is the primary function. The additional water made available as a result of decreased evaporation would presumably be utilized for some economic or social good elsewhere.

Desalting

Present Status

After some 20 years of concentrated research on desalting technology, the mechanics of the most important desalting processes appear to be reasonably well understood.

A variety of processes are being used in desalting. Distillation processes furnish most (nearly 95 percent) of the existing world capacity. About two-thirds of the capacity of the distillation plants use the multistage flash process. Currently, distillation is used almost exclusively for desalting sea water. Membrane processes are used only for desalting brackish water, although recent research has indicated promise for application of the membrane process to desalting sea water as well. Extensive study has been made of dual-purpose plants (plants in which heat produced is used for both power production and for desalting). Existing plants mostly are relatively small, although the newer plants are trending toward larger sizes. The largest plant in operation in the world (as of 1972 at least) has a capacity of 30 million gallons per day; the next largest is only 7.65 mgd.

Desalting costs now are about \$1 per 1,000 gallons for sea water conversion plants and about 50 cents per 1,000 gallons for brackish water plants, measured at the plant boundary. Additional costs for pumping to the place of use also may be necessary since such plants usually are or will be located near sea level. At present, long-range projected desalting

costs are on the order of 25-35 cents per 1,000 gallons at the plant (based on 1972 costs) for large sea water desalting plants and less for brackish water plants. The considerable spread between present costs and those projected emphasizes the fact that efforts to reduce costs of desalting as compared with potential alternatives must be continued if desalting is to become a significant source of water supply. The rapidly rising cost of energy will be a serious negative factor, and sustained efforts to increase plant efficiency and reduce fuel costs will be essential.

Legal Considerations

Fortunately, except for the usual questions of obtaining land use rights and water rights, there do not appear to be many legal restrictions on the use of desalting. Moreover, the water to be desalted normally will be so degraded in quality as to have little value if taken from an inland stream. If sea water is used, the supply for all practical purposes is unlimited, and thus water rights usually are not needed. Obtaining land rights, however, may involve much greater problems because the land to be used may have other important alternative uses. Water quality standards enforcement may require desalting of certain natural springs or effluent discharges.

Environmental Considerations

Environmental effects of desalting include those related to disposal of waste products, that is the salt left in the brine effluent from the plant; the discharge of waste heat from the production of power for desalting and from the plant effluent; the products of combustion when fossil fuel is used as the heat source for power production or for heating distillation process boilers; effect of the plant on land use at the site of the plant and at the place of use of the product water; there may be esthetic effects resulting from the introduction of the plant into the area landscape.

Desalting of water poses additional problems with respect to disposal of the waste products generated. Where the plant is located along a sea coast, disposal into the ocean is a practical solution. For inland areas, unless a beneficial use for these wastes can be developed, additional land areas must be devoted to their storage while keeping them out of both surface and subsurface water supplies. Waste products must be stored or disposed of in ways that give full consideration to effects on various components of local and regional ecosystems.

Artificial Groundwater Recharge

Just as there are situations where the reduction of seepage is highly desirable in managing water, there are also situations where increasing seepage is a desirable practice. To take advantage of subsurface storage reservoirs or to

utilize the soil system to rejuvenate wastewater may require implementation of artificial groundwater recharge measures.

Technical Considerations

The technology of artificial groundwater recharge entails supplementing natural recharge by man-made facilities or by modification of natural conditions. Among the objectives of recharge operations are: (1) replenishment of over-pumped aquifers, (2) injection of air conditioning water from major buildings, (3) underground storage, for the so-called conjunctive use of surface and groundwater reservoirs, (4) improvement of waste effluent quality by taking advantage of soil-filtration, (5) underground mixing of waters of dissimilar chemical composition for quality improvement, (6) creation of fresh-water barriers for inhibition of sea water intrusion, and (7) temporary storage of fresh water in saline water aquifers.

Water supplies for artificial recharge may be storm runoff, sewage effluent, or industrial wastewater. Among the preliminary planning considerations for the selection and design of a recharge facility at a specific site are social and cultural conditions, availability of land, surface hydrological conditions, proximity to water source, and soil and subsurface hydrological characteristics. Depending on these interrelationships between these factors, planners may elect to utilize one or more of the following methods: surface spreading, excavations, or bore holes.

Water spreading entails the release of water over the soil surface in a controlled manner, thereby allowing water to percolate to the water table. The method is generally restricted to land for which there is little demand by developers, or on areas utilized for conjunctive recreation-recharge. Surface and subsurface materials should be highly permeable; the water table should be relatively deep; and the site should be located close to the source of water. Among specific water-spreading methods are: surface flooding, basins, ditches, and modified channel method. Over-irrigation either deliberately or inadvertently may also be an effective way to obtain recharge. Supplies for recharge include flood runoff water, sewage effluent, industrial effluent, imported water, and irrigation water.

Excavations, or recharge pits, are used on sites which are underlain by permeable materials. Some pits are constructed specifically for recharge (e.g., the Peoria, Illinois, pit) whereas others are constructed for gravel pits and later used for recharge.

Bore holes, wells, and shafts, are used for recharge when severe impeding horizons lie between the soil surface and aquifers, or where scarcity of land precludes other methods, or where underground mixing operations are undertaken for groundwater quality control (e.g., Israel). Wells comprise

bore holes extending into the aquifer deposits. Wells may be constructed specifically for recharge purposes or use existing wells. Generally, water supplies for bore hole recharge should be free of sediment and entrained air, to sustain intake rates. Chlorination may be required to inhibit the development of microorganisms. A noteworthy example of recharge wells are those constructed along the Manhattan Beach area of California, serving to develop a barrier to sea water intrusion.

Economic Considerations

Information on relative economic values per unit volume recharged via the various methods is scarce. For four spreading operations in California, Todd (1964) reports an average cost of \$8.26 per acre-foot recharged. Frankel (1970) reports a range of costs of \$6.78 per acre-foot to \$14.80 per acre-foot in Los Angeles during the spreading of storm runoff on seven spreading grounds. These costs include site development, clearing, engineering, fencing, hydraulic control work, and all operation and maintenance costs including supervision. The costs did not include those for right-of-way. Costs for pit operation in California ranged from \$8.38 per acre-foot to \$18.87 per acre-foot, with an average of \$14.55 per acre-foot. In Illinois, at the Peoria site, the average cost of the pits, including amortized capital investment for pits and land, amounted to \$20.97 per acre-foot in terms of 1970 dollars. Frankel indicates that the average costs of 111 injection wells in California, used for sea water intrusion, amounted to \$65,000 per well, including right-of-way and engineering costs. The operation and maintenance costs for these wells (excluding water) ranged from \$9.12 per acre-foot to \$44.40 per acre-foot. If capital costs are amortized over 20 years at 6 percent interest, total water costs would range from \$20.97 per acre-foot to \$71.54 per acre-foot. Harpaz (1971), reviewing recharge wells in Israel, indicated that from an analysis of costs and benefits of nationwide recharge activities, the overall costs of well recharge ranged from \$34.54 per acre-foot to \$59.21 per acre-foot. Recharge techniques, principally water spreading, are currently receiving attention as a method for wastewater reclamation. Frankel (1970) points out that in order for reclamation costs by water spreading to be competitive with conventional wastewater and water treatment costs, the total cost of water renovation would need to be between \$15.24 per acre-foot and \$93.74 per acre-foot. The above values for water spreading operations indicate that such methods fit well within this range.

Environmental Considerations

The recent emphasis on the environmental impact of water-oriented projects is being accounted for by recharge project designers (Scott et al., 1973). Many water spreading projects in California are multiple purpose in that recreational use is an integral part of the design and

operation of the facility. If properly managed, multiple-use facilities are a definite environmental asset.

By "proper management" we mean that care is exercised during operation of water-spreading facilities to prevent esthetic problems (unsightly weed growth, algal blooms, odor problems); health problems (mosquito and other insect problems, stagnant water, groundwater contamination via microorganisms when inadequate soil filtration is allowed); and safety problems (drownings). Recharge wells are generally inconspicuous and therefore create minimal esthetic concern. Concern may arise, however, regarding the possibility of deteriorating the chemical and microbiological quality of native groundwater or causing thermal pollution.

Groundwater recharge appears to be ecologically beneficial so long as contamination by microorganisms and toxic materials is avoided. Storage of flood waters could be ecologically and socially beneficial. With proper planning, surface flooding can provide increased recreation potential while keeping damages to a minimum.

Social Considerations

A major social impact of artificial recharge operations would appear to be the impact of project associated with recreational use. Scott et al. (1973) indicate that the most ambitious multiple-purpose project in California is in the Ontario region, where nine basins on 120 acres are intended to provide picnicking, small boating, fishing, and swimming for a projected 150,000 persons per year and concurrently maintain infiltration rates of 75 acre-feet per day.

The source of recharge effluent may or may not be of concern to users of multiple-purpose recharge facilities.

Legal Considerations

Artificial recharge appears explicitly or implicitly in the regulations of a number of states, or in recommendations for legislation, in the context of establishment of sea water barriers, amelioration of groundwater "mining," or avoidance of groundwater contamination.

Concerned about groundwater "mining," the National Water Commission (1973) recommended: "Where groundwater mining is occurring the States themselves (or local management agencies) should immediately institute regulation of groundwater withdrawal and conjunctive management of groundwater and surface water . . . it can also include artificial recharge, improving infiltration capacity, and other management activities."

Many State and Federal agencies are concerned that groundwater contamination would occur during the accidental or intentional recharge of wastewater and have

promulgated legislation prohibiting such recharge. For example, Section IV of the Arizona Revised Statutes, August 7, 1962, dealing with rules and regulations of the State Department of Health, stipulates that privy content, building drainage, or effluent from any waste treatment facility shall not be recharged via wells or pits into water bearing strata.

Administrative problems associated with recharged waters generally relate to the ability to identify and account for the water. Recharge projects usually benefit large areas or entire aquifers, but the effect on an individual well is difficult to determine. Such water cannot be limited or controlled to a specific area where it can be reclaimed by the agency or project responsible for recharging the aquifer. Water rights for recovery of artificially recharged waters are difficult because of the problem of identifying a beneficial use.

Water Harvesting -- Seepage Control

The control of seepage is often a desirable managerial measure for achieving certain water use objectives. Inadvertant seepage diminishes supplies intended for particular purposes. The seepage waters may in turn cause drainage problems to areas below. Seepage becomes a desirable process in many instances (such as groundwater recharge), and the fact that "seepage losses" are still in the manageable supply of a river system puts them in an entirely different class of loss (so-called) than evaporation. Concerns about seepage losses in the local context may take on an entirely different character when the "third party effect" or broadened boundaries are considered.

Seepage control is the primary measure used in connection with water harvesting. While water harvesting is a special case of seepage control, it is coupled with other measures to store and/or regulate the waters which would otherwise become seepage or surface runoff. While this section dwells primarily on water harvesting, it should be remembered that the technology is quite comparable to that employed in reducing seepage in such other examples as pond and reservoir lining, canal lining, etc.

Water harvesting -- collecting water from soils treated to increase precipitation runoff -- offers the promise of supplying water for certain critical purposes in particularly arid land settings. Through water harvesting, supplies can be provided by capturing precipitation, inhibiting its normal passage into the ground, and storing it for intended uses over time.

Because of the intermittent nature of runoff from precipitation catchments, storage must be an integral part of any water harvesting system. When water harvesting techniques are used for runoff farming, the main storage reservoir will be the cultivated soil itself; but when the

water is to be used for livestock, supplemental irrigation, or human consumption, some type of storage facility will have to be provided. Storage will not always be a problem, however, for it will often be possible to build and locate catchments so as to feed into existing storage structures.

Technical Considerations

Water harvesting is practiced in many ways: by clearing or removing vegetation, by building contour ditches to collect hillside runoff, by treating soil to reduce its permeability, by covering soil with impermeable sheeting, and by building pavements or roof-type structures.

There is a certain potential for utilizing unique physical situations as precipitation collectors. These may include natural areas of large rock or impermeable soil. Man-made structures, such as roof tops, highways, parking lots, airports, etc., might also be used effectively in situations where water supplies thus obtained can show an economic advantage over other alternative supply sources.

The simplest artificial water harvesting structure is a smooth soil surface cleared of vegetation and rocks. When erosion hazards are not excessive and large areas of low-cost land are available, this treatment may be the most economical method for water harvesting.

Compaction of the soil after clearing and smoothing also significantly increases the runoff from some soils. Another method is to install contour ditches along hillsides to reduce the length of travel of the runoff water over the soil and concentrate it in the collection ditch.

A low-cost method of water harvesting involves spraying soils with chemicals that cause them to become water repellent, or hydrophobic. The most commonly used water repellents are silicones and plastics or latex materials.

Relatively small amounts of sodium salts applied to the surface of some desert soils where there is little or no vegetation will cause a dramatic reduction in infiltration rate. These salts cause clay in the soil to disperse and partially seal the pores. The use of sodium salts to increase runoff is intriguing because of (1) its apparent low cost, and (2) these salts are an effective weed control. The treatment is soil dependent and in general is practical only on soils containing 5 to 30 percent clay and substantial amounts of sand or gravel. The quality of the water collected from a chemically sprayed area may limit its usefulness for domestic uses. However, the quality is not generally made unacceptable for use by plants.

In some locations soils that swell with water and become impervious (e.g., bentonite) might be found locally and be used as a surface treatment on otherwise porous soils. Soil cement is a durable treatment, but in general its efficiency

does not warrant the relatively high cost of installation.

A new and unique method is to apply granulated paraffin wax to the soil surface. The granulated wax is melted by the sun and flows into the soil pores to create a water-repellent soil surface that readily sheds water. Molten wax can also be sprayed on the soil surface. Runoff water from a properly constructed wax catchment is of excellent quality.

Sprayed asphalt membranes on suitable subgrades have been found to last for 4-5 years before requiring retreatment. Problems encountered include cracking caused by oxidation, plant germination, and movement in the soil beneath the asphalt. Besides asphalt, other soil binders have been developed, including synthetic rubber latex and oil emulsions, epoxy resins, polymers, and petroleum resins.

Ground covers that have been used for catchment construction can be classified as (1) exposed membranes such as butyl, plastic, and foil; (2) covered membranes, generally using gravel to cover plastic sheeting; (3) sheet metal; (4) concrete; (5) reinforced asphalt; and (6) asphalt planking or asphaltic-concrete.

Exposed covers of plastic sheeting and metal foil offer opportunities for building low-cost precipitation catchments, except that they are easily destroyed by wind and the exposed plastic sheeting is oxidized due to exposure to the sun. Butyl rubber sheeting, although expensive, is more resistant to weathering and mechanical damage.

Gravel-covered plastic film has proven more successful than exposed liners. The gravel protects the underlying membrane against radiation and wind damage but has the disadvantage that part of the water is retained by the gravel and ultimately lost by evaporation. When constructed properly, these catchments are durable, with a projected life in excess of 20 years.

Corrugated sheet metal, such as that used on roofs, has been installed on a timber framework lying on the ground and used as a catchment. Regular concrete and asphaltic-concrete, such as that used for highways, have also been used. These materials, although very durable, are relatively expensive compared to the previously described treatments.

Economic Considerations

The cost of constructing a water harvesting catchment is very dependent on the characteristics of the site. The site will also determine to a great extent the cost of storage, which can be a significant fraction of the total cost. The cost of a typical catchment would range from more than \$10,000 per acre for a butyl ground cover with an efficiency of close to 100 percent, to less than \$200 per acre for a compacted earth catchment that would, under favorable conditions, have an average efficiency of 30-40 percent.

The expected amortized cost at six percent interest of a plastic reinforced asphalt membrane catchment, with a lined reservoir and a floating cover that would produce 165 million gallons per year in a 20-inch rainfall zone, would be approximately \$0.35 per thousand gallons or about \$115 per acre-foot.*

Environmental Considerations

With proper attention to siting and use of cover material, disadvantages to the environment can be minimized. However, the very concept of seepage control or water harvesting in natural settings depends on changing the existing soil and/or plant cover so as to alter the routing path of water received at the ground surface. Therefore, some environmental disturbance is generally inevitable.

Some treatments such as the gravel covered plastic with a rock-filled tank could be made to blend into the western landscape much better than a sheet metal catchment with a steel or butyl rubber bag.

Water harvesting systems on rangeland are normally conducive to a better distribution of livestock. This better distribution would tend to protect overgrazed areas near existing water supplies and thus create an environmental advantage to offset the disturbance of the harvesting facility itself.

Seepage control and water harvesting practices, if restricted to small areas, would have limited ecological effects. Widespread or extensive installations on the other hand could be detrimental. Limiting seepage in small areas would probably not result in any measurable differences in groundwater supply, although lining many channels or ponds might also limit the availability of groundwater. Springs, often a source of water for small streams or marshes inhabited by amphibians, fish, and wildlife could be affected. Seepage control from existing ponds and canals would decrease the amount of vegetation around these systems. In many cases, such weedy and/or brushy zones provide much of the available cover for game birds and animals and the loss of such areas would be detrimental. Before seepage control is initiated, the entire hydrology of a river basin should be studied to minimize adverse effects to the ecosystem.

A combination of water capture and seepage control may also be beneficial if limited to small areas. Increased water supplies, if available to native birds and animals throughout the year, would enable larger numbers to survive during dry years. Such practices are already used by game managers.

Legal Considerations

The principle of water harvesting is to prevent precipitation at a site from being disposed of in its accustomed manner by altering and regulating its routing so that it can meet the supply requirement of some specific use. In this sense, water harvesting is no different from any other kind of development and the same legal questions would apply. If the interception of this water resulted in a measurable change in supply or quality at downstream points of diversion where prior rights are established, it could be denied. If the water harvesting installation merely alters the timing of a depletion that would have occurred naturally, or if it merely results in a decrease in evapotranspiration from natural vegetation in immediate surroundings equal to the increase obtained in the harvesting facilities, then those diverting downstream would not be affected. However, if the harvesting process and subsequent utilization of the water resulted in an evaporative loss where the infiltrated precipitation in the original setting would have found its way back into a stream below, then the harvesting may not be permitted without due process.

Courts have generally held that water salvaged from leaky water systems, such as canals, could be appropriated by the person making the saving. This gives an incentive to install concrete or other lining in canals and ditches or to effectuate other water-saving programs. However, there are times when the seepage resulting from one use furnishes water at another location in the same area for another use and a water right has been established which will be protected by the court. In a relative sense, amounts of water involved in water harvesting processes are generally very small and their use would have imperceptible impact on users below unless there was a high density of installations. Consequently, as a practical matter, there has been very little (or not) objection to their installation and use.

If water harvesting turned out to be an attractive consideration in supplying domestic water for summer homes in semi-primitive surroundings, problems of environmental impact and water rights could become significant problems.

*This was based on an estimate made by B. Cluff, University of Arizona, of a Water Harvesting System for the town of Fredonia in November, 1973.

CONSIDERATIONS OF RESEARCH GOALS AND STRATEGY

Research needs relate to problems whose resolution is essential to achieving some societal objective. Shifts in emphasis and intensification of public interest toward land use planning, energy production and conservation, and general environmental quality suggests that water research programs must give added emphasis to problems arising from these broad concerns.

It will be necessary to enlarge and improve our understanding of water's interaction with its environment and the effects of man's activities on the natural processes. An increased level of research is needed on the effects of reforestation, deforestation, agricultural practices, mining and construction practices, urbanization, etc., and on the quantity, quality, timing, and fate of precipitation occurring in particular areas. Impacts of these land-use modifications on subsequent peak flows, low flow, and groundwater recharge are not well known. Natural and artificial recharge potentials must be known and land-use practices must be carefully evaluated in terms of their impact on recharge of groundwater storage. Most land-use practices create pollution problems of the non-point source variety. Greater emphasis must be given to learning how to trace and control non-point (diffused) sources of pollution related to land-use practices.

Ways must be found to modify institutions to make them more operationally efficient, responsive to needs, capable of accommodating changing technology, and more compatible with vertical and horizontal governmental units to which they relate. Institutional arrangements to better integrate the functions of water supply and wastewater management are needed.

Because increases in certain kinds of quality deterioration of water resources can produce negative and irreversible effects, water quality will continue to be in the forefront of research programs on water resources. Studies will be needed on how to reduce volumes of wastewater; improve processes and techniques for separating various contaminants from wastewaters; and for providing disposal and recycling of materials removed from wastewaters.

The production and consumption of coal and oil shale in the Rocky Mountain Region for meeting the nation's energy needs will pose new problems for the environment. Providing the water supplies and managing the undesirable constituents introduced into the wastewaters from the mining and processing will present a tremendous challenge.

The recreational land sales boom with its impact on water and water pollution has rapidly become a major problem which must have additional research emphasis. Water has an important and persistent effect on the type of land use that is possible whether in natural or man-modified environments. Research is certainly needed to determine the use of water as a major tool in fostering a more acceptable land-use program for the future.

While much recent attention has been given to development of improved procedures for evaluating water resources management so as to be able to maximize net socioeconomic benefits, much remains to be done on this topic.

As previously stated, social goals (local, regional, and national) should be established and recognized if research is to properly respond to the needs and desires of people. If social objectives change, problem emphasis and research priorities change accordingly. If the social goals are fuzzy and water use and development programs lack clear direction, then it follows that the direction of water research programs may also flounder. As a general research strategy, however, some of the following characteristics might be sought:

1. Quick response capability so that solutions are timely and meet user needs.
2. Broad interdisciplinary makeup of research teams with systems perspective.
3. Problem orientation entailing genuine team approach (individuals who communicate and collaborate easily, suppressing individual recognition for team accomplishment).
4. Sophisticated technological skills and tools undergirded with a high social awareness and sensitivity.
5. A sustaining or "backbone" source of financial support to enable retention of top talent in career opportunity; provide more stable and coherent programs in contrast to unpredictable project-by-project programs as with the support of research grants from individual agencies; and minimize inefficiencies and heavy costs in start-up and phase-out.
6. Insulation from pressures of special interest groups and self-serving biases of narrowly oriented mission agencies to assure objectivity.
7. Closer collaborative association with legislative and governmental policy and decision makers.

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**APPENDIX
PRIORITY RESEARCH NEEDS
CRITICAL**

1. Descriptive Title

IMPROVEMENT OF THE WATER LAW AND CONSUMPTIVE WATER ALLOCATION SYSTEMS.

Define the Specific Problem to be Solved

Present water law recognizes only consumptive (usually degrading) use, thus denying use for non-consumptive purposes. The trend in the U.S. is toward environmentally appropriate actions. Thus Western water law is in need of improvement to reflect this trend. Increasing populations, with greater needs for recreation, are not served by present law. The study would be directed at determining how existing laws, policies and administrative decisions affect, favorably or unfavorably, the management of water resources and their recognition of or effect on socially desirable uses of water and adjacent land.

What is the Scope, Geographical Extent, and Importance of the Problem?

This is the most important problem in the Intermountain Region. With greatly increased exploitation of energy resources imminent, a better basis for evaluating and allocating water resources among all users is desperately needed. Widespread destruction of natural streams is probable without a broad based approach. The study would help to indicate why management is generally so inadequate as well as means which would lead to improvements.

What Form of a Solution is Needed? (e.g., instruction manual, research report, process or facility demonstration)

A broad study of various types of water law in the U.S. with an assessment of the effects of both current and proposed laws on the total human community in this region and in the U.S. should result in proposals to devise a more environmentally appropriate set of laws.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

New laws would be widely publicized to be proposed to State and Federal legislatures. Beneficiaries would be the public. Solution would be used by government at all levels. It should help attain greater equity in allocating water uses.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

This problem is of great and immediate concern. Energy-related development in the near future could impose widespread and severe environmental destruction under the present system of laws, with the citizens in this region as the losers. A solution is needed now and delays may mean further costly or poorly conceived decisions.

2. Descriptive Title

SOCIOLOGICAL CONSIDERATIONS IN THE PLANNING OF WATER RESOURCE USES.

Define the Specific Problem to be Solved

We are experiencing a collision of water resource objectives in the Intermountain West because of large demands upon our shrinking water base. This collision is the result of single-purpose, usually consumptive, use of water by special interest groups. We need to involve the public in decisions regarding use of our water resources so that maximum benefits can be realized from our water resources.

What is the Scope, Geographical Extent, and Importance of the Problem?

Competition between consumptive and non-consumptive water uses in the arid and semi-arid areas of the Rocky Mountain area is increasing. The social and economic needs of the people must be balanced with environmental needs so that economic growth and environmental priorities can be compatible. We must attempt to obtain the side use of our water so that non-consumptive uses such as outdoor recreation can be enjoyed in addition to consumptive uses such as diversions for irrigation.

What Form of a Solution is Needed?

In the past, decisions on use of water resources were made by special interest groups with little involvement of the public. Major changes have evolved recently in attitudes and opinions of the public toward the environment. We need input on water resource planning for the public so that we can satisfactorily weigh environmental concerns against economic needs. The benefit will be maximum use of our water resources.

How will the Solution be Used, by Whom, and What Benefits May Accrue?

Techniques used by the social scientists should be employed to determine social needs of the public in water resource planning.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution has been needed for some time. The pressures for growth and development, as well as for recreation, will continue to increase. Deferring the problem may result in losses to recreation where the consequences of certain water uses are irreversible.

3. Descriptive Title

IMPROVING PUBLIC PARTICIPATION IN WATER PLANNING AND MANAGEMENT.

Define the Specific Problem to be Solved

Further study needs to be made of the way in which more effective public participation can be attained in the areas of water planning and management. This should include case studies of past experience where public participation has been effective or ineffective in terms of its influence on the final product; and of the impact of various public information and educational programs. The research should be directed toward identifying the means by which the public can participate more meaningfully in the process of planning for and considering alternatives.

What is the Scope, Geographical Extent, and Importance of the Problem?

This problem exists throughout the Nation. The problem is critical because the public is increasingly concerned about land management activities, but effective techniques for involving this concern in the decision-making process are not yet known.

What Form of a Solution is Needed?

Research reports, process demonstrations, and case studies would be useful to help decision makers use this valuable report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

A real solution to better public participation could be used by all levels of government and by the public generally. It would have the effect of making the governmental processes more satisfactory to people. Land managers in particular could respond more appropriately in planning for the use of public land.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution is needed now. A delay simply means continuation of the lack of trust and confidence which now exists.

4. Descriptive Title

ENVIRONMENTAL AND ECOLOGICAL IMPACTS OF LAND MANAGEMENT PRACTICES.

Define the Specific Problem to be Solved

Means to minimize the environmental impact of watershed management practices should be more completely identified, including consideration of game and non-game species of wildlife; esthetics; nutrient cycling; and stream-flow color, temperature, taste, and chemical content; and other factors. Much emphasis is being placed on the extraction of minerals and energy sources because of their potential in the Rocky Mountain Region.

What is the Scope, Geographical Extent, and Importance of the Problem?

This knowledge would have general utility, but would probably be localized for particular situations or problems. The problem is important because the ecological and environmental consequences of many land management practices are not completely understood. The importance of the problem is particularly acute since the public pressure for development of new energy and mineral sources is increasing in the Rocky Mountain West.

What Form of a Solution is Needed?

Research reports, operational guidelines, and demonstration areas could all be used to advantage in the dissemination of this information.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The information would be used by ecologists, hydrologists, land managers, resource policy makers and others. The environmental and ecological consequences of land use processes will be much better understood and weighed in the decision-making process. In addition, the information will help minimize impacts on wildlife and other aspects of natural ecosystems.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now, but should be incorporated on an incremental basis as new knowledge is acquired. If this research is deferred, the information may not be available when it is needed most.

5. Descriptive Title

APPLICATIONS OF DECISION-MAKING TECHNIQUES IN NATURAL RESOURCES MANAGEMENT

Define the Specific Problem to be Solved

The objectives of watershed management practices often involve many products and values, including water, that have complex interrelationships, which must be integrated and analyzed in a decision-making framework. Modern techniques of systems analysis which seek to integrate the power of quantitative analysis with the concepts of economic theory may provide a means to this end. Consequently, efforts should be intensified to adapt systems theories to the process of decision making in watershed management.

What is the Scope, Geographical Extent, and Importance of the Problem?

In principle, these techniques will have general utility but would probably be localized for particular problems or situations. The application of these powerful decision-making techniques should significantly improve the ability of land managers to analyze increasingly complicated problems.

What Form of a Solution is Needed?

Research reports and operational manuals or guidelines would be two forms of information transfer in this case.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The solutions would probably be used by land managers and policy makers, giving both increased power to make optimal decisions.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now, but can be incorporated on an incremental basis as new knowledge is acquired.

6. Descriptive Title

INDUSTRIAL IN PLANT RECYCLING OF WATER.

Define the Specific Problem to be Solved.

Industrial water users are presently taking process water on a "once through" basis with either limited treatment before discharge or containment of effluent and evaporation as treatment.

What is the Scope, Geographical Extent, and Importance of the Problem?

The importance of this problem lies in potential multiple uses of water. "Once through" water uses with full containment and evaporation reduces the potential of water use to possibly one application. Scope of the problem may be limited to upper basin users where return wastewater may be limited by high quality stream conditions.

What Form of a Solution is Needed?

The solutions needed are in the form of process designs for water recycling to reduce water diversions and the design of wastewater facilities based on new guidelines regulating effluent conditions of water returned to the streams. A research report must be generated on the industries involved to present a case for lower water use and return flow from the primary use.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solutions will be used by State and Federal agencies to adjust water usages and provide more water for multiple uses. Overall benefits would be determined by study. It would appear that all future water users could benefit from lower water usage and high ratio of return flow.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now for plants operating with high water usage factors and for consideration of new plant design. State agencies should be encouraged to have guidelines for efficient water use and return flow researched.

7. Descriptive Title

RIVER BASIN MANAGEMENT PLANS ON MULTI-STATE REGIONAL BASIS.

Define the Specific Problem to be Solved

Problems of land use, water use, resource development and population buildup by river basins would be the specific thrust of the management plans. Solutions would be offered through research to actually define management procedures compatible with the regional uses and demands.

What is the Scope, Geographical Extent, and Importance of the Problem?

Scope would be limited to common areas of a river drainage basin. Upper basin uses would be combined for a Step I phase. Mid and lower basin plans would be prepared concurrently. Step II phase would combine these management plans.

8. Descriptive Title

BASIN-WIDE AND INTERBASIN WATER RESOURCE PLANNING.

Define the Specific Problem to be Solved

Water supply varies seasonally, from large surpluses to deficits. Some users manipulate supplies to suit their uses without regard to others. Since all users are appropriating public water, all should cooperate in proper management of the system. Precipitation/snow-melt predictions, reservoir storage capacity, power generation needs, recreation, irrigation and urban needs could be programmed to develop a system of management to smooth out the supply of water.

What is the Scope, Geographical Extent, and Importance of the problem?

Surplus water in the spring and shortage in late summer characterize much of the Intermountain Region. Manipulation of reservoirs, seasonal pumped storage and redesign of irrigation systems might in combination equalize benefits from water use.

What Form of a Solution is Needed?

A combination of research report and demonstration would be necessary, first to locate and assemble necessary information, and then to demonstrate to water users that the plan was indeed workable.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solutions could be used by county and/or regional governmental units. Benefits would include reduced flooding in spring with increased supply in summer. It should help agencies to avoid some of the errors of the past and both save money and assure proper consideration of all interests.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

This is a problem today, and predicted increases in water demand will accentuate the problem.

9. Descriptive Title

STATISTICAL ESTIMATION OF THE PHYSICS AND BIOLOGY OF TOTAL WATERSHED SYSTEMS AND THE CONSTITUENT PROCESSES

Define the Specific Problem to be Solved

The physical and biological system will probably not be amenable to quantification in a fundamental sense for many years. Therefore, statistical approximations of the constituent processes individually and in combination will provide decision makers with interim prediction tools for estimating the hydrologic and environmental consequences of various land management practices.

What is the Scope, Geographical Extent, and Importance of the Problem?

Such statistical models and tools would have general utility in principle, but would probably be localized for particular problem areas. The problem is significant because land management practices will probably be instituted with or without such knowledge. The management decisions could be much more rational if such prediction tools were available.

What Form of a Solution is Needed?

Much of the information would be provided initially in the form of research reports.

What Form of a Solution is Needed?

Solution is needed in the form of research reports on Step I recommendations for conservation and reclamation of resources, and Step II management manuals with recommended demonstration projects.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solutions will be used by Federal, State and local management agencies as each new demand is proposed for resources in the basin.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Problems could be summarized within a short period of six months with load uses and water demand. Solutions and recommendations on development of a basin management plan would be needed within a calendar year.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The solution would be used by hydrologists, land managers, and in a more general way by policy makers who would acquire improved knowledge of the hydrologic consequences of various land management practices.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now, but can be incorporated on an incremental basis as new knowledge is acquired.

10. Descriptive Title

ALTERNATIVES TO STREAM CHANNELING.

Define the Specific Problem to be Solved

Stream channels are altered for a variety of reasons, but the results are usually a reduction in standing crop and productivity of desirable fish. Information is needed on the extent and duration of benefits to those promoting channeling as well as an assessment of primary and secondary costs to the environment, environmental users and taxpayers. Benefits are often short lived, but habitat disruption may suppress fish populations for many years.

What is the Scope, Geographical Extent, and Importance of the Problem?

From 30 to over 70 percent of the stream length in various parts of the Intermountain West has been altered by channeling. In some areas one must travel considerable distances to fish natural streams. With such recreational uses of water increasing and fuel supplies decreasing, some other options must be found.

What Form of a Solution is Needed?

Research to establish the effectiveness and length of service of various options and the resulting response of fish populations should precede reports and demonstration projects.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution could be of use to governmental agencies involved in channel alteration as well as to land owners. Benefits would accrue to land owners, sportsmen and the general public.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

This is a crucial, current problem. Stream channel alterations occur regularly, and in view of the length of time required for recovery, great amounts of stream will be lost for many years as a result of channeling activities each year.

11. Descriptive Title

EFFECT OF REDUCED STREAM FLOWS ON AQUATIC COMMUNITIES.

Define the Specific Problem to be Solved.

Water from many streams in the Intermountain West is being diverted or stored for irrigation. These practices result in low flows by summer. The productivity of stream ecosystems is limited by extremes in streamflow. Because of the increasing demand for outdoor recreation and its impact on stream fisheries, managers are becoming more concerned about manipulations of aquatic ecosystems. Consideration must be given to recreational development of water resources as well as to uses considered more traditional.

What is the Scope, Geographical Extent, and Importance of the Problem?

Many states are now establishing minimum flow requirements for fish and other aquatic life. This is especially a problem in the Intermountain West because the minimum flows occur at the time of the year when the greatest demand occurs for other uses such as irrigation.

What Form of a Solution is Needed?

Research must be accomplished that will demonstrate to what degree fish are affected by reduced stream flows. In addition, we must establish criteria to determine minimum streamflow requirements.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Priorities for all water uses must be set at the regional level in the Intermountain West because of the widespread ecological, social, and economic impacts from most water uses in this area. The public would benefit from increased recreational opportunities if minimum streamflows were established and maintained. It should be possible to review water uses on a watershed basis so that recreational opportunities can be expanded while allowing use of our water resources in conventional ways as well.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

We should begin immediately to make intelligent decisions on water use by considering beneficial uses of water and establishing priorities for use after careful analysis has been made. Deferring the problem may result in loss of streams for recreation.

12. Descriptive Title

EFFECTS ON AQUATIC ECOSYSTEMS OF PESTICIDES, HERBICIDES, AND OTHER POLLUTANTS FROM IRRIGATION PRACTICES.

Define the Specific Problem to be Solved

Various chemicals, such as pesticides and herbicides that are used in farming practices, enter into our waters via irrigation return flows. In addition, increases in salt content and turbidity also occur from return flows. These pollutants have a detrimental effect on aquatic ecosystems.

What is the Scope, Geographical Extent, and Importance of the Problem?

Irrigation places the heaviest demand on the water resources of the Intermountain West. For instance, about 85% of Utah's farms are now irrigated and about two-thirds of Utah's irrigated land need additional water. We need to determine the origin of various pollutants, define the chemical or material, and determine the effects of these pollutants on aquatic life.

What Form of a Solution is Needed?

Field studies should be carried out that will document the effect of these pollutants on aquatic ecosystems and even man. Laboratory studies should be conducted to find acceptable substitutes that will not be harmful or that will decompose more readily.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Research reports that document which chemical or materials cause most of the damage will help State and Federal agencies to regulate use. We will need to seek other chemicals that will control various pests or weeds but that have less effect on aquatic ecology. The benefits will be cleaner water for the well-being of the entire public.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution is needed now. Deferring the problem will result in even greater accumulation of chemicals that do not decompose readily and that are known to have detrimental effects on all life including man.

13. Descriptive Title

REFLECTING ECOLOGICAL AND ENVIRONMENTAL FACTORS IN SYSTEMS ANALYSIS AND MODELING STUDIES.

Define the Specific Problem to be Solved

Large-scale interbasin transfers, if and when they are undertaken, will have significant implications to both the source and receiving areas. These will not be one-time effects, but continuing and likely changing effects which must be known and understood if the system is to function well. Modeling and other advanced techniques will be needed. But these techniques will not be effective unless they can be made to include, reliably, ecological and environmental factors.

What is the Scope, Geographical Extent, and Importance of the Problem?

The West is the primary focus although the Great Lakes and some areas in the East also may be involved at some time. The problem is important in that such transfers may not be possible until their effects can be analyzed and predicted.

What Form of a Solution is Needed?

Research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution will be primarily important to Federal and interstate groups who must plan to meet the future demands for water for many purposes.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

While the solution would be useful now, it will become most important within the next 10 or 15 years. Failure to develop a solution may mean decisions on a much less satisfactory analytical base.

14. Descriptive Title

EVALUATION OF EFFECTS OF WATER TRANSFERS ON SOURCE AND RECEIVING BASINS.

Define the Specific Problem to be Solved

Water transfers impose social and ecological costs on both import areas (increased population and loss of prime agricultural and wildlife habitat) and export areas (loss of much of the water-based recreational values and foreclosure of future options for development). Studies should include geology, soils, fishery, climate, vegetation, historical and archeological resources, land uses, esthetics, and other relevant factors.

What is the Scope, Geographical Extent, and Importance of the Problem?

Water transfer is common today in the Intermountain Region, and will become even more prevalent in the future. Projected energy-related projects will require vast quantities of water in regions short of water. National energy demands are acute and exploitation of these sources is certain.

What Form of a Solution is Needed?

A combination of research reports and process demonstrations by a broad interdisciplinary group would be most useful. University, agency, governmental and industrial participants would be required.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Governmental units and agencies involved in developing and evaluating transfers need a basis for evaluating plans. NEPA requires such evaluation, but development-oriented agencies are not capable of the necessary evaluation. Benefits would include better long range comprehensive planning.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Immediately. Widespread and immediate initiation of energy-related projects is probable with water development following closely. This scenario would include continued failure to properly evaluate consequences with resultant, often unwise, and damaging transfers based on single use concepts.

15. Descriptive Title

DEVELOPMENT OF IMPROVED SHORT- AND LONG-TERM WEATHER FORECASTING FOR APPLICATION TO THE MANAGEMENT OF NATURAL RESOURCES.

Define the Specific Problem to be Solved

The improvement of short-term and long-term weather forecasting may simplify and improve hydrologic prediction efforts. It may also improve land management decisions pertaining to such matters as prescribed burning, revegetation, and logging operations which can cause watershed damage or result in failure.

What is the Scope, Geographical Extent, and Importance of the Problem?

Such knowledge would have general utility everywhere, but would be localized for particular situations. The information may save lives and reduce damage to the natural resource base.

What Form of a Solution is Needed?

Research reports and operational guidelines would be among the forms of information dissemination.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The solution would be used by hydrologists and land managers and would involve many kinds of private organizations and government agencies.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now, but can be incorporated on an incremental basis as new knowledge is acquired.

16. Descriptive Title

WATER QUALITY FIELD STUDY AND SALINITY MODEL FOR BASE WATER QUALITY CONDITIONS.

Define the Specific Problem to be Solved

Waste water return flow and tributary streams in major river basins would be studied to determine present water quality.

What is the Scope, Geographical Extent, and Importance of the Problem?

Discharge permits are required for municipal, industrial, and agricultural effluents (point and non-point sources). A determination of contributing sources would be made to identify components of natural and man-made waste flows. Reasonable permit limitations would be determined on waste water from combined sources. Identification would be by river basin conditions of uses of water and land.

What Form of a Solution is Needed?

Procedures must be developed for field studies of water quality, a computer model developed for salinity control, and an instruction manual prepared for use by water user groups.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution would be used by Federal agencies to prepare guidelines, for State agencies to establish base water conditions and for user groups to monitor discharge conditions.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed by mid-1975 for reasonable values to be set as effluent conditions. Consequences of unreasonable values set for discharge conditions can be expensive in lost time and wasted efforts (money and manpower) to water users and enforcement agencies.

17. Descriptive Title

MODELING ARTIFICIAL GROUNDWATER RECHARGE.

Define the Specific Problem to be Solved.

Develop models of the effects of recharge on regional groundwater levels and mound formation and dissipation using finite differences and finite elements techniques. Develop field techniques to study the underground mixing of recharge effluent and native groundwater. Develop models to facilitate prediction of groundwater quality during various mixing operations.

What is the Scope, Geographical Extent, and Importance of the Problem?

The problem applies to groundwater basins, in all regions where recharge is practiced. The project is important in facilitating plans for groundwater basin management. Research is necessary in areas where native groundwater quality may be deleteriously affected by recharge (e.g., well injection) or where blending is desired. A universal problem. Highly important.

What Form of a Solution is Needed?

Computer models, demonstrations, research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution will be used by groundwater basin managers, planners, etc. and will facilitate predicting effects of practices on long-term water levels. Solutions will be used to predict quality of groundwater during planned or unplanned mixing operations. Will be used by planners and managers. Benefits will accrue to all water users.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed as soon as possible. Deferment will prolong planning for basin management.

18. Descriptive Title

MEASUREMENT OF RECHARGE QUANTITY AND QUALITY.

Define the Specific Problem to be Solved.

Determine more accurately the quantity of water and water movement in the soil and substrata under conditions of refilling and dewatering (unsaturated and saturated conditions). Also determine when, where, and in what concentrations salts will be leached to the water table under recharge due to irrigation and to artificial practices.

What is the Scope, Geographical Extent, and Importance of the Problem?

Universal problem in water spreading operation and recharge pit operation.

What Form of a Solution is Needed?

Research into measurement techniques -- both lab and field. Coupled with research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

It will be used to predict more accurately the quantity and quality of recharges by operators and managers and will assist in avoiding contamination. It will be used in guiding the planning and management of facilities by managers, operators of projects, etc. Benefits will be that the maximum amount of water will be available for recharge.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solution needed immediately. A consequence of deferment is that some groundwater basins might become polluted because effective detection methods are not available.

19. Descriptive Title

CLOUD SEEDING CONTROL LEGISLATION.

Define the Specific Problem to be Solved.

To develop model State laws governing the seeding of clouds.

What is the Scope, Geographical Extent, and Importance of the Problem?

Interstate and regional conflicts are likely to arise due to cloud seeding operations.

What Form of a Solution is Needed?

A "model" State law to be used by State legislative assemblies. It should facilitate research, protect public interests, and provide compensation for damages.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Few States have enacted any legislation to control cloud seeding; existing laws generally call for permits to be issued.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Critical; deferral will only delay adaptation of systematic controls and lead to unnecessary litigation and loss of public regulation.

20. Descriptive Title

RESEARCH ON THE ACTUAL FORMULATION AND IMPLEMENTATION OF MANAGEMENT PLANS.

Define the Specific Problem to be Solved

In spite of the fact that there are many reports presenting "management plans," few if any are more than single purpose or at most dual purpose plans. What is needed for a basin or part of a basin is a comprehensive plan. It should take account of all possible functions which the stream and its flows may serve and of the most effective way of accomplishing those which are possible. Several carefully selected watersheds should be studied in depth.

What is the Scope, Geographical Extent, and Importance of the Problem?

This has nationwide value. The watersheds selected should be distributed according to geographical location and types of problems. There simply is no feasible alternative to improved management.

What Form of a Solution is Needed?

Research report, instruction manual and process demonstration.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The result should provide a basis for greater effectiveness of water planning and managing agencies in all parts of the Nation. State and Federal agencies will benefit most in better management of watersheds.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

It is needed now. Probably most other research will not be fully utilized without this kind of application of theory and practice to real situations.

URGENT

21. Descriptive Title

METHODS OF EVAPOARTION CONTROL.

Define the Specific Problem to be Solved.

Methods that need to be studied further include the use of airplanes to maintain a monolayer of alcohol; bubbling of air to reduce the surface temperature during the day; diking off shallow portions of large reservoirs; etc. Improve present methods involving the use of floating covers.

What is the Scope, Geographical Extent, and Importance of the Problem?

The first methods are suited primarily for large reservoirs. The scope may well be limited to specialized situations unless costs can be reduced. The scope of floating covers is limited primarily to reducing evapoartion on smaller reservoirs whose primary purpose is one of water supply. Individually these reservoirs are not of great economic importance, but collectively they are very important, not only in this country but worldwide.

What Form of a Solution is Needed?

Primarily a process and/or facility demonstration with a research report on same.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

In specialized situations when the value of water is high. The benefits derived from having a standby system of evaporation control available for use during periods of extreme drought should be worth additional expenditure in this area.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution could be used in specialized situations where the value of water is high. Delay in its development could cause problems, particularly in time of extreme drought.

22. Descriptive Title

EVALUATION OF SEEPAGE CONTROL TECHNIQUES.

Define the Specific Problem to be Solved

The development of a systematic method of evaluation of methods and materials available for seepage control.

What is the Scope, Geographical Extent, and Importance of the Problem?

The scope, while international, is of particular importance in arid and semi-arid lands where water storage is a problem.

What Form of a Solution is Needed?

A system for specifying research reports.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Consulting engineers, farmers, ranchers, etc. will benefit by receiving updated, accurate, unbiased seepage control information from a central source.

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When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution has been needed for some time. Deferring on the problem will result in expenditure of unnecessary effort and funds in controlling seepage loss.

23. Descriptive Title

AUGMENTED WATER SUPPLIES FOR URBAN DEVELOPMENT.

Define the Specific Problem to be Solved

Increased migrations of people into urban areas of the arid west will cause increased demands for water supplies to satisfy municipal needs, including the provision of environmental amenities such as lakes and parks. These new urban needs will require intensified research efforts in watershed management to maximize the productive use and conservation of limited precipitation inputs.

What is the Scope, Geographical Extent, and Importance of the Problem?

These techniques should have general utility, but would probably be localized for particular problems or situations.

What Form of a Solution is Needed?

Research reports would probably be the initial form of information dissemination.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Hydrologists, land managers, resource policy makers and others would find this information useful. More ample water supplies would increase the opportunities to satisfy the economic and personal needs in urban environments and could provide environmental amenities.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed in the near future, but can be incorporated on an incremental basis as new knowledge is acquired.

24. Descriptive Title

WATER QUALITY EFFECTS OF USING URBAN EFFLUENT FOR IRRIGATION.

Define the Specific Problem to be Solved

What will be the effect on surface water and groundwater quality from the use of urban effluent for irrigation? Of industrial effluent? There is a need to determine and demonstrate whether or not urban and industrial effluent can be used without danger to health.

What is the Scope, Geographical Extent, and Importance of the Problem?

Large quantities of urban and industrial effluent could be used but are not being used for irrigation. One of the concerns is the effect of such use on the quality of the surface and ground waters. A solution could be of value in all parts of the Nation, but particularly in the water-scarce areas.

What Form of a Solution is Needed?

Research report and process demonstration.

How Will the Solution be Used, by Whom, and What Benefits May accrue?

By water administering and water quality agencies, water management agencies and individuals. Could result in considerable increase in water supplies, and could reduce pressure for developing other sources.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Could be used now; will become more essential as supplies become more completely utilized for other competing purposes.

25. Descriptive Title

LEGAL CONSTRAINTS ON WATER REUSE, RECYCLING, AND WATER RECLAMATION OF MUNICIPAL AND INDUSTRIAL WASTEWATER.

Define the Specific Problem to be Solved

Research the present laws governing the reuse of water in various states of the Rocky Mountain Region. Classify the water reuse and recycling possibilities and changes in state law required to allow water reclamation.

What is the Scope, Geographical Extent, and Importance of the Problem?

Water laws will vary state by state. Each concerned area (state or group of states) would need a review study and classification of water by uses and reclamation.

What Form of a Solution is Needed?

Research report would be formulated from basic laws. Second step would be classification of reclamation uses with recommended demonstration projects of significant water reuse.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solutions will be used by state agencies and water users. Research will give figures and facts on benefits of water reuse. More water will be released for future use.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions will be needed within one year to keep pace with resource developments in which water is a key factor.

26. Descriptive Title

ECONOMICS OF MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT.

Define the Specific Problem to be Solved

Research is needed on various treatment facilities for industrial and municipal wastewater systems (either individually or jointly. Treatment facilities would include in-plant treatment, in-line treatment, and wastewater treatment facilities. Total financing and payout considerations would be summarized for the treatment systems.

What is the Scope, Geographical Extent, and Importance of the Problem?

Areas of concern would include waste sources from both industrial and municipal sources in specific areas where reuse of water is practical.

What Form of a Solution is Needed?

Solutions are needed in the form of research reports where water treatment for reuse can be presented on an economical basis. Wastewater could be supplied to a treatment facility by a city to be treated by industry for their reuse.

How will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution can be used by water users, regulating bodies. Benefits would be realized by recovered nutrients and water reclamation funds.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions to force better management of water are needed now. Research into economics of water reclamation will be necessary within the next two years.

27. Descriptive Title

IMPACT OF FLUCTUATING WATER LEVELS OF RESERVOIRS ON AQUATIC LIFE.

Define the Specific Problem to be Solved

Reservoirs used as pumped-storage electric power sites or for irrigation have an unstable water level. In the first case, the reservoir may fluctuate daily while in the second case, the fluctuation may be seasonal. Many aquatic communities are not able to cope with these fluctuations. Therefore the productivity of the ecosystem can be reduced.

What is the Scope, Geographical Extent, and Importance of the Problem?

The competition for water use for electric power and irrigation in the Intermountain West has, and will continue to have a great impact on the reservoir environment. Fluctuating water levels may lower the recreational potential of these waters. Because of an increasing demand for fishing, reservoirs will become even more important for recreation in the arid and semi-arid Rocky Mountain States.

What Form of a Solution is Needed?

An evaluation should be made of the effects of fluctuating water levels on fishery resources.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Detailed evaluations can be used in decisions regarding the use of these waters. Local and regional agencies will be primarily involved in making these decisions. To insure that the public's interests are protected, decisions should be made only after considering public attitudes.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

A solution is needed now in some areas. The need will become more critical with time because we can use reservoirs for the production of fish for sport, protein for market, or fish meal to feed livestock, in addition to other uses.

28. Descriptive Title

PROTECTION OF STREAM BANKS FROM GRAZING ANIMALS.

Define the Specific Problem to be Solved

Cattle severely damage stream banks when allowed free access to streams. The results are eroding banks, wide shallow stream channels, lack of stream bank cover, and few fish.

What is the Scope, Geographical Extent, and Importance of the Problem?

This is a common problem everywhere, but of great importance in mountainous areas where there is little fencing. These areas are also important recreation areas.

What Form of a Solution is Needed?

Research reports and demonstrations.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Land management agencies could adjust their procedures to provide grazing yet protect stream banks. With time banks would stabilize, providing improved fish habitat and increased fish populations for recreation.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

This solution is needed now. Delay will allow additional damage to streams. Recovery is slow.

29. Descriptive Title

NUMERICAL CLOUD MODELS.

Define the Specific Problem to be Solved

To develop numerical models describing the behavior of layer clouds, orographic clouds, synoptic storms, and severe local storms.

What is the Scope, Geographical Extent, and Importance of the Problem?

Necessary to the extension of cloud seeding technology beyond the limited case of local cumulus cloud systems.

What Form of a Solution is Needed?

Numerical models which describe and predict the state of a weather system and changes to be expected if seeding is practiced.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Used by scientific and technical groups to perfect the technology.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Urgent; deferral will delay potential extension of the technology.

30. Descriptive Title

RELEASE OF SALT DURING WEATHERING PROCESS IN THE SOIL.

Define the Specific Problem to be Solved

An understanding is needed of the rate of release by soil weathering and the influence on this rate of differing quantities of irrigation water. Study of leaching as a process to better understand how frequency and mode of irrigation affect the maintenance of a salt balance in the soil system.

What is the Scope, Geographical Extent, and Importance of the Problem?

Extremely important in areas such as the Colorado River Basin where the water is already quite saline.

What Form of a Solution is Needed?

Research report and possibly process demonstration.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solutions will be used by individuals and by Federal and State agencies.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Needed now. Failure to resolve will have an impact on future water quality programs.

31. Descriptive Title

DESALTING RESEARCH NEEDS.

Define the Specific Problem to be Solved

The continuing research in desalting should give attention to: (1) processes that have a high ratio of output per unit of energy input (this of course has always been true, but the energy scarcity emphasizes the importance) and on means of increasing end ratio of product output per unit of feedwater; (2) research on brine disposal methods; (3) means of integrating desalting into existing systems, its use for staging, for interim uses, and for conjunctive uses, on its use in water quality and improvement programs. (4) research on ecological effects.

What is the Scope, Geographical Extent, and Importance of the Problem?

The solution of the various parts of this research can have a value to most parts of the country. The more arid parts would find the results most valuable.

What Form of a Solution is Needed?

Research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The solution will be used by Federal, State and local water planning and administering agencies and by those responsible for implementing plans.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The results could be used now, but the need for them will mount with time.

32. Descriptive Title

MULTIPURPOSE CONSIDERATIONS IN ARTIFICIAL RECHARGE.

Define the Specific Problem to be Solved

Explore approaches to make recharge facilities or areas multipurpose, such as use as recreational areas, wildlife habitats, and for esthetic improvement of the environment.

What is the Scope, Geographical Extent, and Importance of the Problem?

Problem in urban and rural areas in all regions where recharge facilities may serve multiple purpose function. Solution of the problem is not urgent, but would be beneficial.

What Form of a Solution is Needed?

Facility demonstration.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution would be used by planners and developers in guiding construction -- benefits would accrue to passive users of facilities.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solution is not needed immediately, but deferment might prevent or deter involvement of facilities in multiple purpose usage.

IMPORTANT

33. Descriptive Title

RELATIVE VALUE OF WATER FOR COMPETING PURPOSES.

Define the Specific Problem to be Solved

Where water is scarce and choices must be made between competing uses, there is a need for a better means of judging the relative value of the various uses to society.

What is the Scope, Geographical Extent, and Importance of the Problem?

It may have application in any part of the U.S., but is particularly important in the water-scarce areas of the western states.

What Form of a Solution is Needed?

Most useful might be a research report that defines the value of water on a comparative basis for making trade-off decisions.

How Will the Solution be Used, by Whom, and What Benefits May accrue?

Results will be useful to Federal agencies, but most useful to State and local agencies who must make choices between competing uses or applications for use.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solutions are needed now. Delay simply means the best data are not available for adequate decision making.

34. Descriptive Title

DETERMINE FACTORS WHICH TEND TO DETER EFFICIENT IRRIGATION.

Define the Specific Problem to be Solved.

Increasing efficiency of on-farm water use may or may not increase the effective water supply. Because of the widespread misunderstanding of this fact, studies need to be made to determine the conditions where increased efficiency will have the effect of increasing the effective supply because of either quantity or quality considerations.

What is the Scope, Geographical Extent, and Importance of the Problem?

Of importance primarily in the West, the problem is very important wherever the demand for water exceeds the supply.

What Form of a Solution is Needed?

Research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Use will be made of the solution by Federal, State, and local water agencies, which could result in both increased efficiency and greater productivity.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring the Problem?

Results are needed now.

35. Descriptive Title

MEANS TO IMPROVE APPLICATION OF FLOOD PLAIN MANAGEMENT.

Define the Specific Problem to be Solved

Flood plain management appears to be the best means in many cases for preventing flood damages and preserving desirable ecological and environmental values. Yet in spite of much study and effort, it still is not being applied to any extent. This study would be directed at learning why the technique is not being applied and the means by which it can be made to function better.

What is the Scope, Geographical Extent, and Importance of the Problem?

Very important in all parts of the Nation where there are significant streams.

What Form of a Solution is Needed?

Research report, instruction manual.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

It will be used by Federal, State, and local flood control and land planning agencies.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution is needed now. Failure to make flood plain management function as a tool will be very costly.

36. Descriptive Title

INTERRELATIONSHIPS BETWEEN WEATHER MODIFICATION ACHIEVEMENTS AND NATURAL RESOURCE MANAGEMENT PRACTICES AND CONCERNS.

Define the Specific Problem to be Solved

If weather modification experiments prove successful enough to warrant consideration for operational applications, much more information will be needed on the hydrologic and ecological consequences of increased precipitation regimes.

What is the Scope, Geographical Extent, and Importance of the Problem?

The scope is general, but operational implementation will probably be limited primarily to mountainous terrain. The effect of augmented precipitation regimes on natural ecosystems and runoff characteristics of watersheds would be understood prior to implementation.

What Form of a Solution is Needed?

Research report, operational guidelines, and actual demonstration areas would provide a means for information dissemination.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The information would be used by hydrologists, ecologists, land managers, and resource policy makers. All benefits and possible detrimental effects should be considered prior to implementation.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring the Problem?

The solution will be needed if and when weather modification proves to be feasible. The solution should not be deferred beyond this time, since otherwise operational implementation might be recommended before the consequences of such an action are fully understood.

37. Descriptive Title

REDUCED WATER HARVESTING COSTS.

Define the Specific Problem to be Solved

Further reduce costs of treating soils for the collection of precipitation.

What is the Scope, Geographical Extent, and Importance of the Problem?

Vast amounts of land in the Western United States and the world will never be further developed unless water is made available. The development of economical water harvesting techniques could provide water for these lands.

What Form of a Solution is Needed.

Process and/or facility demonstration with research report.

How Will the Solution be Used, by Whom, and What benefits May Accrue?

The solution will first be used for stockwater and domestic supplies. If the cost is low enough, it would be used to collect water for agriculture.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

The solution is needed now. Deferring on the problem will only result in building more expensive, energy-consuming water systems.

38. Descriptive Title

INSTITUTIONAL ARRANGEMENTS TO FOSTER WATER HARVESTING.

Define the Specific Problem to be Solved

To determine what changes in institutional arrangements are needed to promote the proper use of water harvesting systems.

What is the Scope, Geographical Extent, and Importance of the Problem?

The scope could be international but will probably have to be worked out for each country.

What Form of a Solution is Needed?

A research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

Solution can be used in each country for which the research is done. Benefits will accrue to water users, particularly those in less inhabited, remote areas where water harvesting is particularly applicable.

When Will the Solution be Needed and What are the Consequences, if Any, of Deferring on the Problem?

Solution is needed before wide-scale water harvesting can be implemented. More expensive, energy-consuming alternate water systems could be built if solution is delayed.

39. Descriptive Title

RESEARCH ON UNDERSEA TRANSFERS OF WATER

Define the Specific Problem to be Solved

Since much of the Nation's population lives along the sea coast, the physical opportunity appears to exist for transferring blocks of water from the mouth of a stream to another location along the coast through use of an underwater conduit. This would eliminate some of the ecological and environmental problems in the headwater areas, but it could add others along the coast. There is need for a continuing study to develop the techniques of such transfers and a determination of the fishery and other resources of the coastal areas.

What is the Scope, Geographical Extent, and Importance of the Problem?

This could have applications directly and indirectly to much of the Nation. Probably by the turn of the century or before, this approach will need to be considered seriously.

What Form of a Solution is Needed?

Research report.

How Will the Solution be Used, by Whom, and What Benefits May Accrue?

The solution will be used by Federal, State, and interstate bodies and by various interest groups.

When Will the solution be Needed and What are the Consequences, if Any of Deferring on the Problem?

A solution should be available within ten to fifteen years. Unless this approach proves possible, greater pressure will be placed on the headwaters as a source of water.

S Y N T H E S I S

R E P O R T



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PART III

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SYNTHESIS WORKSHOP REPORT

INTRODUCTION

Between the expanse of blue sky and red cliffs of the Grand Canyon, approximately 100 individuals gathered from April 29 to May 3, 1974, drawn together by a shared concern about the planned use, conservation, and preservation of the Rocky Mountain Region. The importance of keeping resource use options open for future generations pervaded the workshop.

This gathering was the climax of a year-long effort by Rocky Mountain Environmental Research -- Quest for a Future (RMER-Quest) to identify the most critical environmental research needs for the Rocky Mountain Region.

To accomplish the primary work of the project, namely, the identification of problems and research priorities, it was decided first to divide the work into eight subject areas. The groundwork for the Synthesis Workshop was laid by these eight preceding task force reports which examined the state-of-knowledge and identified the existing gaps in knowledge in their respective fields and the consequent research needs. At the conception of RMER-Quest it was recognized that a division of labor into these eight task force areas would provide the rapid mobilization of people and ideas necessary to the preparation of short, but comprehensive reports within six months. At the same time, it was recognized that such a disaggregation of the project's scope would result in some amount of unavoidable duplication and omission as well as the need eventually to re-synthesize results.

In order to provide an integrated report, this 3-5 day Synthesis Workshop was designed so that approximately 40% of the participants, who had not been involved in RMER-Quest previously, joined the remaining 60% which consisted of individuals who had been deeply involved in the project's work. All participants were sent copies of the task force reports and asked to read them thoroughly in order to achieve the following workshop goals:

- A. To review the task force reports and the reviewers' comments and identify important themes (or threads) between the reports as well as "gaps" not covered by the reports.
- B. To identify the major, significant environmental problem areas of the present and the future in the Rocky Mountain Region.
- C. To identify the most important research priorities that would emerge from considerations at the workshop. This included four types of research-related matters: (1) research projects; (2) research programs (or directions); (3) ways to improve research methodology; (4) ways to improve research implementation.

These goals were to be met by bringing together the knowledge held by participants of varying backgrounds. Invitations were extended to university researchers in a

variety of fields; to private and public administrators; to elected officials; to state and federal agency personnel; to industry representatives; and to environmental and citizen organizations. It was believed that the continued flow of communication between a large number of people from various interested groups would give greater assurance of producing well-documented, broadly based research needs statements. It was anticipated that a report representing such a broad base of ideas would have a greater chance of being accepted and implemented.

The diversity of individual backgrounds played a large role as the workshop participants attempted to develop criteria for weighing the many research recommendations. Philosophies, ranging from complete preservation to "full speed ahead" development, were well vocalized. Individuals rejecting traditional research met head on with researchers interested less in social problems or decision making than in pure research. Within the range of viewpoints, most participants sensed an urgency in planning the future of the Rocky Mountain Region. However, within the time structure of the workshop, the participants were unable to give priority to those research needs which would be the most critical. In addition, there was difficulty in arriving at consensus on what the significant regional problem areas are now and will be in the future. Consequently, the research needs which follow are an agglomeration of all the research needs cited and do not represent a consensus or majority acceptance by the group.

A framework under which these varying research needs could be presented was developed after much debate and persuasion. This framework is reflected in Chapters I-III of the Table of Contents. Chapter One of the outline, THE ROCKY MOUNTAIN REGION: AS IT IS TODAY, reflects the need for resource inventory research. Chapter Two, THE CHANGING SYSTEM, reflects the need for long-range planning tools in order to manage for a future. These two chapters are conceptual presentations and are followed by the pertinent research needs in Chapter Three. Within Chapter Three, the subject headings A-H represent those areas most commonly stated as important at the workshop. The research needs within each subject area are sectioned into "Inventory," "Response to Imposed Change," and "Directing Change." Research needs germane to "The Region in National and International Perspective" were not separated into a distinct section, but listed within the groupings of "Response to Imposed Change" and "Directing Change" in the respective subject areas.

Since the task force reports were used as a foundation and reference for the Synthesis Workshop, the research needs presented in these reports have been referenced to the task force reports. The reference may be found directly following each research need.

CHAPTER I: THE ROCKY MOUNTAIN REGION: AS IT IS TODAY

A. INVENTORY OF THE REGION'S CHARACTERISTICS AND THE PROCESSES AFFECTING THEM

Having defined the study region to include the Rocky Mountain States, the associated high plains and the intermontane plateaus, it is necessary to inventory its characteristics. Both the state properties or characteristics¹ and the processes² by which each property interacts with another must be determined for the Rocky Mountain Region. State and process information will provide a baseline from which to ascertain (and possibly control) the direction and degree of change occurring in this Region.

The Rocky Mountain Region as it exists today is determined by a wide variety of conditions. Some variables are relatively unchanging, such as soil types, geology or topography, while others, such as population growth and weather, are more dynamic. Process studies have the advantage of providing information which is applicable over a wide range of conditions and can utilize many arrays of static information. Thus, process studies can be applied as a long-range predictive tool. However, over the short run, questions will undoubtedly arise necessitating the measurement of state variables. By definition, these are site specific. Realizing the amount of time and money needed to inventory all the sites (nearly infinite) within the Rocky Mountain Region, we do not see this as a valid task. However, to identify those areas within the Region which might be considered "critical" and then to proceed with a static inventory and process study would provide useful information.

Environmental impact statements are now being prepared to deal with a multitude of "critical" situations. A major problem for those responsible for such statements is the lack of inventory or baseline data from which to evaluate the potential impacts of use. Of major concern then, is the formulation of guidelines by which to select the critical areas.

¹The state of a system is the condition of the system at any point in time. It is described by number of properties such as temperature, density, and height.

²A process is something that is measured over time; the rate at which a given phenomenon occurs.

B. THE REGION IN NATIONAL AND INTERNATIONAL PERSPECTIVE

Because the Rocky Mountain Region has been used as a resource bank by the rest of the U.S., the term "neo-colonialism" is sometimes applied regarding its economic and political status. The Region has long sold its resources too soon at too low a price. But now it is beginning to challenge this history.

At the same time the Rocky Mountain Region citizens realize that they are not isolated, but are interdependent with the rest of the Nation and the world. Goods and services flow readily in both directions across its borders. Its interactions with the Nation and the world are renewed daily. The present international demand for U.S. food and fiber is increasing because of drought-induced harvest decreases in other nations. This increasing demand includes demand for crops, animals, minerals, and timber from the Rocky Mountain Region. The increasing demand is in addition to the continuing increase brought on by regional, national, and international population growth and per capita consumption.

Demands often conflict with each other for renewable and non-renewable resources. For instance, a national demand for strip-mined coal located under especially scenic land within the Region may conflict with a regional demand for recreational opportunities. We need to determine which of the Region's resources significantly involve national or international demand.

These extra-regional influences must be examined in order to realistically appraise the options available to the Rocky Mountain Region.

Since many major decisions about and affecting the use of resources in the Rocky Mountain Region are made outside the Region, the Region in national and international perspective would merit study. Such a study might consist of analyzing the capital flow, sources of capital, etc., in and out of the Region. A study of the flow of capital might identify the decision makers and would lead to a better understanding of the basis of decisions affecting the Region. It might also provide insight pertaining to what types of information might aid in the decision process, or provide insight as to what type of public action would be most appropriate to accomplish socially desirable objectives. This problem may be too massive to undertake *in toto* but might be possible through studies concentrated on particular industries such as energy, minerals, land sub-division, recreation, timber, etc.

Another question is: Where are the capital centers for investment in the Region for various commodities? For example, for the northern part of the Region, capital needed for investment in lacquer mills related to the timber industry comes from Minneapolis.

The relation of government activity and investment (or lack of it) has a direct relationship to industrial investment and activity. With foresight, government investments can influence private investment in desirable directions or discourage undesirable activities. Government investment in research can also be directed toward maintaining or expanding alternatives concerning industrial and technological development.

The Federal Reserve regions reflect the financial zoning of the Nation and run counter to the Rocky Mountain regional boundaries. In fact, it may be that flow of capital and the Federal Reserve regions actually draw us apart as a region. From a capital viewpoint, the Rocky Mountain Region represents the hinterland of the Nation.

"The Region in National and International Perspective" has been treated conceptually in this separate section in order to emphasize its importance. The specific research needs, however, are addressed in Chapter Three, within the categories "Response to Imposed Change" and "Directing Change." Both such categories deal with interface arrangements.

CHAPTER II: THE CHANGING SYSTEM: RESPONSE TO IMPOSED CHANGE AND DIRECTING CHANGE

Realizing that the Rocky Mountain Region is caught in a process of accelerating change, it is important to address the question of change directly. The Rocky Mountain Region is not an isolated colony. Rather, it reacts to both the internal and external demands of a people, a Nation, and a world. Regional institutions inevitably must respond to these demands (often conflicting) through decisions made either consciously or by default. Two dramatically different approaches used by institutions to manage the various demands are: (1) to respond to change and (2) to direct change. These two approaches have varying impacts in shaping the future of the Rockies. Each subject area within CHAPTER III: RESEARCH NEEDS, includes research needs under these two headings.

With various demands on resources modifying the environment, our goal is to minimize the adverse environmental impacts by planning for wise resource use. Bearing this in mind, it is beneficial to examine the general differences and similarities between the two approaches and to determine where and how each is utilized most effectively.

Responding to change does not necessitate a "policy." It is an after-the-fact reaction to deal with an existing problem or situation. Most efforts are made to accommodate in a beneficial manner the motions already begun. For instance, in an established wilderness preserve planned to include unlimited backpacker use, a forest ranger might try to minimize damage to an alpine meadow caused by an increased number of hikers. Likewise, a state planner might assist in locating the construction site of a power plant within a specified area, while the decision to build the plant at that area had already been made.

In contrast, directing change does imply a policy. Vectors are aligned to reach a specific goal. It is a conscious before-the-fact attempt to navigate a charted course. Citizens must determine the type of region they want and then initiate the action and sacrifices necessary to obtain that environment. Some consciously directed changes which have significantly shaped our environment were (1) those resolutions by Teddy Roosevelt to create national forests within the Region, and (2) Richard Nixon's decision to help meet the "1980 energy independence" goal by the promotion of oil shale exploration in the Rockies.

It is interesting to note that in both the establishment of national forests and oil shale leasing within the Region, the Region itself was in the position of responding to imposed change, while the executive office of the Federal Government was the director. Similar decisions affecting regional resources may be made at the state or local levels, but most major decisions affecting our use of resources in the Rocky Mountain Region are made outside the Region. A major problem within the Region is that in the past we almost exclusively responded to both internal and external forces. Up until the last decade, most conservation-oriented programs/institutions were created outside the Region. In the future, the Region needs to take a leading role in initiating such arrangements.

Another interesting point is that the genesis of action occurs within an institution if it is directing change; whereas, the genesis of action is external to the institution if it is responding. This is associated with the relation of cause and effect. In the history of this Region, the ratio of the population to the resources was sufficiently low that an individual's actions did not have a significant effect on a great number of people. The need of personal constraints was minimal. As the density of people increased, the conflicts over resource use increased. The causes and effects of an action now impact more individuals directly and indirectly. The luxury of the Wild Free West is no longer a reality. The resolution of conflicts often then must be resolved through public institutions. A responding institution does not see the need to regulate individuals' actions since it is not examining the source of a conflict but rather its effects, whereas a directing institution must limit individual action if it is to cause change.

In fact, many actions of the individual are limited today. Some relationships are now easily identified by the public, and control is accepted. The need for traffic lights at intersections reflects this. The relationship between the cause (carelessness, impatience) and the effect (possible death) of traffic accidents is obvious, and therefore public acceptance of directional control is high. However, in considering natural resources, the cause and effect relationships are not clear to much of the public; consequently, regulation is opposed.

Research which clarifies the interrelationships of natural resources and people's actions is therefore critical, especially since controversy and emotions are involved. Once the relationships are identified, there is a need for applied research either responding to or directing change. Consequently, research needs reflecting these ideas respectively follow the inventory section of each subject area. These research needs are presented in the next chapter.

CHAPTER III: RESEARCH NEEDS

A. HUMAN POPULATION: THEIR NEEDS, RESPONSES, AND DEMOGRAPHY

The majority of the population in the Rocky Mountain Region is concentrated in high density urban centers, while the remainder of the population is highly dispersed within the vast area of the rural landscape. Variations occur from one section of the Region to another; for example, each of the states in the Rocky Mountain Region (with the exception of Wyoming) has urban centers in which most of its population is concentrated. That population, however, utilizes the surrounding rural and public lands in a variety of ways. Not only is this land used for outdoor recreation, but also for its resources such as minerals, water, timber, and forage necessary to maintain the vitality of the urban centers.

The vastness of the Region with its low population density presents unique problems. There is a high dependence upon the automobile for intraregional travel, with little thought given to mass transit until recently. People's desire to own and live on their private pieces of land (the little place in the country; the ten acre ranchette) is growing more and more prevalent. This generates the common pattern of urban sprawl, which, in turn, necessitates dependence on the individually owned auto. Thus, a lifestyle is created which necessitates high-energy consumption because people must commute great distances for employment, shopping, recreation, etc. This lifestyle may be incompatible with the long-range quality of the Rocky Mountain Region.

The population of the Rocky Mountain Region is not homogeneous in its beliefs, preferences, or ethnic backgrounds. What one Coloradoan desires, a Utahn may despise. Little is known about the variety or similarity of the values and behavior of the Rocky Mountain Region's inhabitants. Although all may love the diversity of the landscape, each may have a differing view as to what should be done with it. As the value of land rises with increasing demand, a farmer, tired of milking twice each day may seek freedom by selling his land to a developer. Someone else who views the farmlands as a serene and necessary part of the landscape may become infuriated by witnessing the rolling wheat fields concreted into homes. How can these conflicts be resolved? What are the social and economic costs a citizen must bear to support a subdivision. . . what are the social and economic costs he must support to prevent its development. . . how much is he willing to pay?

In order to answer such questions, it is necessary to understand the existing situation. We need to know the static and dynamic qualities of the population. The existing attitudes, preferences, values, and needs of the people in the Region can provide baseline data by which various changes can be measured.

With the development of various resources in the Rocky Mountain Region, demographers predict an increasing rate of population growth. It is felt that these types of changes will have an influence on the attitudes of the people to the point where their *needs, preferences, and values* might be changed. These changes, in turn, may have an effect upon the types of uses to which the Region will be put with consequent impacts on its environment. Not only must the potential change in population be understood, but the consequent changes in their values, preferences, and needs must also be understood.

If an increase in regional population occurs, due to immigration or internal growth, there may be an increase in conflict between the new arrivals and native population. Legal questions may arise which have never before been confronted. Are there methods of limiting the concentration of people in a given land area? Can, in fact, a human carrying capacity be determined and have legal meaning as a controlling mechanism?

To answer such questions, RMER-Quest recommends research into the following areas:

INVENTORY

1. Survey the existing values of the Region by culture.

- a. Do the citizens of the Rocky Mountain Region have unique values, attitudes, and behavior?

*Refs: Mineral and Energy, II-D-29 (#36a); II-D-30 (#43)
Recreation and Tourism II-E-6 (B)
Rural Residential Development, II-F-17 (#4.2)*

- b. How do values change? What is the process of value/preference formation?

- (1) How are values represented by behavior?
(2) What are the effects of people's actions (representing their values, preferences, etc.) on the environment?

*Refs: Recreation and Tourism, II-E-10 (I)
Human Needs and Responses II-B-2 (#1)*

- c. Identify which "regional needs" may conflict with "federal needs." What are the long- and short-term impacts to the environment of meeting one versus the other? Which diverse regional values conflict or are compatible with one another?

*Refs: Recreation and Tourism, II-E-11 (A)
Institutional Arrangements, II-C-6*

- d. How do people's values support or constrain regional public and private planning and decision making?

Ref: Timber and Forage, II-G-7

- e. Determine the meaning of "quality of life" to various sectors of the regional population.

2. Can these values be quantified, or aggregated?

*Refs: Human Needs and Responses, II-B-2 (#3-4);
II-B-10; II-B-12
Institutional Arrangements, II-C-4 (#4)*

- a. Is this necessary in order to set priorities concerning growth and development?

3. What are the biological requirements and desired secondary requirements ranging from survival needs to luxury needs?

*Refs: Recreation and Tourism, II-E-10 (A,B,C)
Rural Residential Development, II-F-17 (#4.1)*

- a. How do we educate ourselves to differentiate our luxury needs as perceived from survival needs?

- b. Given a quantity of resource, what are the present personal priority uses? How may we create personal priority uses? How may we create personal standards for resource uses? Can these be met on a voluntary basis?

- c. What is the effect of advertising techniques on stimulating needs?

4. Develop a system of assessing the values of the Rocky Mountain Region's nonmarketable natural resources, archeological, historical and societal amenities (e.g., open space, scenic vistas, parks, sound of water).

*Refs: Recreation and Tourism, II-E-4 (E); II-E-4 (H);
II-E-10 (E)*

- a. Identify national preferences for the Region's endemic landscape types: Northern Plains, Canyonlands, etc.

- (1) Determine the impacts of proposed landscape alterations on residents' patterns of settlement.

- b. How can such values be incorporated into decision-making processes?

*Ref: Timber and Forage, II-G-4 (#vii)
Human Needs and Responses, II-B-13 (#3)*

5. What is the relation of the various lifestyle preferences to resource use?

Ref: Recreation and Tourism, II-E-15 (E)

- a. For different lifestyles, what are the material and energy requirements, income requirements, work and leisure time available, and physiological and psychological consequences (mortality, mental health and illness)?

- b. What are the effects of lifestyle changes on the intensity and sequence of land and resource development?

6. How do regional subcultures view the resources of the Rocky Mountain Region (minerals, timber, scenic areas, recreation) and their development potential?

*Ref: Recreation and Tourism, II-E-14 (B,C,D); II-E-15 (F,G,H,K)
Mineral and Energy, II-D-29 (#36B); II-D-27 (#28b)*

7. What are the total energy investments for various population dispersions? What is the energy cost of living in suburban, urban, or rural America? In second homes? In recreational communities?

Refs: Recreation and Tourism, II-E-6 [C,E]; II-E-7 [J]

8. Complete an in-depth analysis of the present and probable population structure, including:
 - a. Locations of the centers of settlement within the Region.
 - b. Present employment patterns.
 - c. Attributes of natives of the Region (age, education, sex, etc.).
9. What are the internal and external variables controlling the present regional growth rate?
10. What are the present rates of immigration and emmigration in the Rocky Mountain Region?
 - a. What are the personal attributes of the immigrants/emigrants (age, values, income level, education, and sex)?
 - b. What are the sources of in-migration?
 - c. What is the seasonal influx?
11. Compare the growth and functioning of prototype Rocky Mountain Region communities.

Ref: Recreation and Tourism, II-E-6 [A]

12. How do population centers evolve?
 - a. New towns (second-home or energy development).
 - b. Boom towns (other than energy related).
 - c. Growth centers (Boulder, Salt Lake).
 - d. Communities.
13. Determine optimum size levels for communities and legal tools to cut off their growth.
14. What is the status of land ownership in the Rocky Mountain Region -- absentee, transient, speculative, resident, etc?

RESPONSE TO IMPOSED CHANGE

1. What is the motivation for immigration into the Region?
 - a. What factors change population and urbanization trends?
 - b. What factors cause people to move to a particular area within the Region?

*Refs: Timber and Forage, II-C-4 [i and ii]
Mineral and Energy, II-D-25 [#19a]*

2. Identify the impacts of pending population changes and patterns on the Rocky Mountain Region.
 - a. Where is future growth most likely to occur?
 - (1) Examine settlement patterns for the past 10 years and project them for the next 5-10 years.
 - b. What will be the impacts of immigrating populations on existing communities (resource use, rural economies, political institutions)?

*Refs: Institutional Arrangements, II-C-9 and 10
Mineral and Energy, II-D-25 [#19i]
Rural Residential Development, II-F-15 [#1.5]*

- c. What is likely to be the permanence of new residents?
- d. What would be the impact if the population growth rate reached zero and immigration stopped?

DIRECTING CHANGE

1. Conduct a local and regional study to determine the population distribution and demographic characteristics with a low, predicted, and high population growth.

Ref: Mineral and Energy, II-D-25 [#19B]

- a. What is the probable environmental impact of the assumed population change, based on what these people will be doing?

Ref: Institutional Arrangements, II-C-9

- b. What are the demands for social services (transportation systems, water and sewage disposal, energy, food and fiber, communication and education systems, etc.) for these three projections?

*Refs: Mineral and Energy, II-D-25 [#19c,d,e,f,h]
Rural Residential Development, II-F-17 [#4.6]
Institutional Arrangements, II-C-5 [#5]
Timber and Forage, II-C-4 [vii]
Water Resources, II-H-39 [#18]*

2. Determine areas ecologically suitable for high density urban developments.

3. Within the context of the Constitution of the United States, develop workable methods of controlling and distributing the quantity of inborn and immigrating human populations to the Rocky Mountain Region.
4. Can the Rocky Mountain Region create a regional self-image or consciousness?
5. Determine a "quality of life" goal to be utilized by regional decision makers.
6. Identify the variables that affect the long-term carrying capacity alternatives for communities in the Rocky Mountain Region

B. RENEWABLE AND NON-RENEWABLE NATURAL RESOURCES

The variety and high quality of natural resources in the Rocky Mountain Region are an important aspect of the Region's uniqueness. As the resources become relatively more scarce because of resource depletion, population increases, and greater demand, there will be a greater pressure within and external to the Rocky Mountain Region to develop the regional resources.

How will such pressures be dealt with? We need to answer such questions as: (1) shall we develop our resources; (2) to what extent and in what manner shall we develop; and (3) what will be the impacts of the varying degrees of development on the regional environment? Will strip-mining of oil shale be allowed in this Region? If a company strip mines tomorrow, how are the spoils to be revegetated? Who pays this cost: the industry, citizens of the Region, citizens of the Nation? However, before questions such as these are answered, it would be helpful to arrange completed basic and applied research relevant to environmental assessment of development into a form usable by decision makers. Although much basic research has been completed concerning regional timber and grazing problems, water allocation and quality, fish and wildlife, etc., gaps in the spectrum of basic information about our natural resources remain. It is therefore, important to examine what new inventory research should be conducted.

The inventory research should be conducted in a manner which would provide comparable results (so that data concerning plant absorption of carcinogens produced from oil shale could be assessed in the light of data on carcinogens produced from coal). Findings must be in a form usable by decision makers.

In response to the scarcity of resources, a special focus should be placed on research emphasizing the environmental impact of the use of renewable versus non-renewable resources. The maximum efficiency of the use of each of these types of resources, as well as their potential for reuse

should be examined. Such a focus would provide information which the Region could use if it chooses to direct which resources are, in fact, developed and in what manner.

RESEARCH NEEDS COMMON TO ALL NATURAL RESOURCES

INVENTORY

1. Estimate potential demands on regional resources (minerals, timber, energy fuels, wildlife, wilderness areas, etc.).

a. What are the causes of resource demand?

b. How can demands be controlled?

2. Develop an inventory system to provide knowledge of the full range of land resources and their interrelationship needed for sound land management.

*Refs: Recreation and Tourism, II-E-4 [G]; II-E-15 [J]
Timber and Forage, II-G-8
Mineral and Energy, II-D-27 (#28c)*

3. Update resource inventories and present the information in atlases. Include such resources as: natural biota, agriculture lands, watersheds, recreational areas, population characteristics, industrial parks, etc.

*Refs: Mineral and Energy, II-D-16 [#1]
Biological Resources, II-A-4 [#1]; II-A-5 [#4]
Institutional Arrangements, II-C-6 [#3]*

4. Develop monitoring systems (in connection with the basin-wide planning system required under the Water Pollution Control Act Amendment of 1972) throughout the Region in cooperation with federal, state, and local agencies and universities.

Ref: Water Resources, II-H-30 [#3]

5. Identify critical regional resources and determine their distribution, uses, possible substitutes, and the impacts caused by varying degrees of exploitation.

*Refs: Biological Resources, II-A-4 [V.A]
Mineral and Energy, II-D-27 (#28a)*

- a. What resource constraints will impose the earliest limitations on resource development and environmental quality in the Rocky Mountain Region?

6. What is the efficiency of our resource utilization?

Refs: *Rural Residential Development*, II-F-13 [1st Col. #6 and #8]
Mineral and Energy, II-D-29 [#40]

- a. Conduct studies to identify waste in this Nation and its potential value as a resource.
- b. Develop the technology and institutions capable of recycling water; minerals; human, agricultural and industrial wastes; dwellings; building materials; etc.

Refs: *Water Resources*, II-H-35 [#12]
Rural Residential Development, II-F-16 [#2.3]
 II-F-17 [#3.8]

- c. What are possible further uses of effluent water in our biotic community?

Refs: *Water Resources*, II-H-23 [para. 4]; II-H-9 [para. 4].

MINERAL AND ENERGY

INVENTORY

1. Determine within the Region the total energy investments for various:

- a. Population dispersions;
- b. Transportation systems;
- c. Manufacturing processes;
- d. Agricultural practices;
- e. Exploration, extraction, processing, distribution, and use of renewable and non-renewable energy resources.

Ref: *Timber and Forage*, II-G-1 [#ii]

2. What are the environmental impacts of mining and energy development?

- a. Does the impact of people's use of minerals exceed the impact of extraction or vice versa?
- b. What are the impacts of the various extraction methods? What is the feasibility of multiple mineral extraction?

3. What are the possibilities/problems of recycling minerals?

- a. What energy savings are gained by processing recycled minerals versus processing virgin ore?

4. Revise mineral and energy inventories to encompass reserve quantity changes reflecting changing prices and technological feasibility.

5. Establish criteria and goals for revegetation of disturbed lands. Is it sufficient to:
 - (1) Gain soil stability?
 - (2) Retain original vegetation and animal population?
 - (3) Maintain self-sustaining vegetation cover?
 - (4) Examine long range effects of exotic species?

Refs: *Mineral and Energy*, II-D-16 [#2]; II-D-23 [#4.3]

- a. What are the various potential uses for disturbed lands and their short- or long-term environmental impacts; e.g., uses as campgrounds, fishing areas, golf courses, study areas, natural protected areas, etc.

- b. What are effective methods of revegetating mine spoils in the Rocky Mountain Region?

Ref: *Mineral and Energy*, II-D-23 [#10]

- c. Identify factors (slope, rainfall, soil, etc.) that can determine the success/failure of revegetation and therefore the feasibility of mining.

Refs: *Mineral and Energy*, II-D-24 [#s 12, 13, 15]

- d. Identify vegetation types, especially native species, which can be used to retain disturbed areas.

Refs: *Mineral and Energy*, II-D-24 [#14]; II-D-26 [#24]

6. Determine the effect of fossil fuel extracting, processing, and burning operations on rare and endangered species.

RECREATION

INVENTORY

1. Define the nature and characteristics of tourism and recreationally-oriented communities within the Rocky Mountain Region.

Refs: *Recreation and Tourism*, II-E-4 [A,F,I]; II-E-15 [I]
Mineral and Energy, II-D-27 [#28 f, g]

- a. Assess the opportunity for access to recreational areas of low social contact.
2. Determine the social/psychological values of wilderness and open space. What will the public pay or forego to have wilderness and open space?
 - a. What is wilderness? Does "wilderness" exist in the Rocky Mountain Region?
 - b. Does a wilderness area in the absence of management tend to revert to a state disliked by humans?
 - c. What are the social, economic, and environmental impacts of wilderness preservation management?
 - d. What are the long-term effects of wilderness areas on water supplies, water resource management, and watershed efficiency?
 - e. Can watershed management and wilderness preservation be compatible? What are the conditions?
 - f. Should any agency having administrative authority over a wilderness area be required to file an Environmental Impact Statement under the provisions of NEPA before acting on management plans?
 - g. What is the impact of shorter work week/increased leisure time on Rocky Mountain wilderness areas?
 - h. What alternatives to wilderness are acceptable to different publics?
 - i. What causes people to choose recreational experiences involving different levels of social contact?
3. What factors influence the production and manipulation of wildlife for its own sake?
4. Identify endangered and rare plants and animals within the Rocky Mountain Region.
5. What are the impacts of ski areas on the Rocky Mountain environment?
6. Determine the impacts of proposed landscape alterations upon the behavior of non-resident tourists and settlement patterns of residents.

WATER

INVENTORY

1. Determine the impact on biological species of water resources manipulation.

Refs: Water Resources, II-H-38 (#47); II-H-39 (#19); II-H-41 (#21); II-H-42 (#24); II-H-50 (#37)

- a. Determine the impact of stream channelization on aquatic ecosystems.

(1) What are the sociological implications, e.g., loss of recreation facilities, esthetic loss, public preferences.

2. Inventory existing water supplies, including allocations, uses, and means of protection.

Ref: Mineral and Energy, II-D-26 (#20)

3. Inventory the natural water recharge patterns in the Region.

*Refs: Mineral and Energy, II-D-26 (#20)
Water Resources, II-H-50 (#38); II-H-51 (#39)*

4. Determine the long- and short-term effects of both natural and artificial impoundments on the upstream and downstream waters.

*Refs: Mineral and Energy, II-D-26 (#20f)
Water Resources, II-H-42 (#23)*

5. What biological changes result from various forms of weather modification (cloud-seeding, sheet harvesting, etc.)?

Refs: Water Resources, II-H-44 (#26); II-H-43 (#28)

TIMBER AND FORAGE

INVENTORY

1. Complete an ecological history of the grasslands.

*Refs: Recreation and Tourism, II-E-5 (J)
Timber and Forage, II-G-1 (#iii)*

- a. What are the biological impacts of hunting on game and non-game species?
- b. Conduct a big game census.
- c. What is the seasonal distribution of game animals? of non-game animals?
- d. What are the impacts of shale oil extraction on wildlife?

Ref: Mineral and Energy, II-D-26 (#25)

2. Determine the economic and environmental cost of each method of timber harvesting.
 - a. Develop ways and means of harvesting with minimum amount of roads and traffic through forest areas.
3. Assess the regional and national timber needs for regional timber.
 - a. Is it possible to fill these needs? What is the role of the private tree farm?
 - b. What is the effect on the environment if we supply these needs?
4. What are the ecological consequences of "chipping" versus "clearcutting"?
3. Examine the structure of communities in proximity to environmental amenities, and their relationship to the amenities resource base.
4. Determine mechanisms for applying existing sociological information to "boom town" problems.

QUESTIONS OF HEALTH

INVENTORY

1. Can carcinogenic materials travel through the root systems of plants and be transferred to man via ingestion?
 - a. Is there carcinogenic material from coal gasification (e.g., in leftover tars), and is this leached through the soil and subsequently absorbed by plants?
 - b. Are carcinogens present in spent oil shale?
 - c. Can carcinogens be transferred to the food chain by rodents ingesting contaminated salts?
2. Are there any unique health threats due to pollution in the Rocky Mountain Region? Are these threats increased or decreased due to low altitude or high altitude?
 - a. What are the effects of carbon monoxide in high altitude environments?
3. Are there health problems associated with trace elements released in the mining and processing of coal?
4. Inventory the potential hazards to the health and normal functioning of the society caused by natural perturbances or technical failures.

Refs: Mineral and Energy, II-D-26 (#23), II-D-27 (#27)

- a. What problems are unique to the Rocky Mountain Region that would develop from a power blackout? Would isolated communities in winter need air drops of fuel and food?
- b. What knowledge is needed concerning naturally polluted water?
- c. Conduct advanced studies in avalanche research to improve forecasting techniques as well as snow mechanics.
- d. What is the significance of catastrophic environmental events on native ecosystems, resource exploitation, and land-use planning (e.g., fires,

AGRICULTURAL

INVENTORY

1. What is the total energy investment for various agricultural practices?
2. What is the effect on agricultural production if water is reallocated to mineral and fuel development?

Ref: Water Resources, II-H-33 (#9)

3. With an impending world-wide food problem, should the Rocky Mountain Region be encouraged to participate in stepped-up food production?
 - a. What would be the environmental costs?
 - b. Should arid lands be cultivated?
 - c. What would be the required energy subsidy for various levels of increased production?

SECOND HOMES

INVENTORY

1. What are the environmental impacts of various degrees of urbanization in rural areas?

Ref: Rural Residential Development, II-F-15 (#1.2)

- a. How can the environmental impacts be minimized? What are the trade-offs?
2. What are the existing socioeconomic processes affecting urbanization (including small towns, large cities, and suburban sprawl)?

earthquakes, avalanches, accidents involving radio-active materials)?

5. Inventory methods of viral detection.
6. What health changes are posed by underground nuclear blasting in the Rocky Mountain Region?
7. How do various levels of radiation from the following sources effect health in the Rocky Mountain Region?
 - a. Houses on tailings;
 - b. Mining uranium;
 - c. Living near nuclear plant;
 - d. Test sites in Nevada;
 - e. Nuclear stimulation of oil shale and natural gas.
8. Examine environmental health problems arising from coal-fired plants.
 - a. Examine respiratory disease increase in Durango, Colorado.
 - b. Does crop damage occur near coal-fired plants?
9. Determine measures of personal health and illness (physical and mental) for the Rocky Mountain Region.
 - a. Using hospital data, find out how the use of the environment is impacting people (especially emphysema, cancer, mental stress).

Ref: Rural Residential Development, II-F-16 (#2.2)

RESPONSE TO IMPOSED CHANGE

1. Identify the total costs, benefits, and trade-offs (including cumulative costs) of disrupting or converting self-maintaining natural systems to substantially man-modified systems.
 2. Determine multiple use trade-offs for use of all natural resources.
- Refs: Recreation and Tourism, II-E-8 [H]
Mineral and Energy, II-D-27 (#26)
Water Resources, II-H-34 (#10)
Rural Residential Development, II-F-15 (#2.1)*
- a. How may these trade-offs be evaluated?
 3. Determine the environmental consequences of setting aside richest coal/timber, etc., areas for maximum use

and setting aside all other marginal resource areas for non-use.

4. How may the Region accomodate an increased demand for outdoor recreation? Identify various user groups and design recreational programs for them.
 5. What are the social and environmental consequences of continued development of environmental amenities-based communities and related services?
- Refs: Rural Residential Development, II-F-15 (#1.3)*
- a. What will be the effects of increased demand for new towns?
 - b. How many second homes can the Region accomodate?
 6. How will the amenity resources and their associated communities and transportation systems be impacted by other developments in the Region (e.g., electricity generation in the Southwest, oil shale development in Colorado and Utah, and coal development in Wyoming and Montana).

Ref: Rural Residential Development, II-F-15 (#1.6)

DIRECTING CHANGE

1. Research alternative energy sources, i.e., solar, geothermal, wind, tidal, organic matter.

*Refs: Mineral and Energy, II-D-26 (#22)
Timber and Forage, II-G-4 (#1)*

- a. To what degree will increased demand for these renewable energy resources (such as solar, tidal, organic matter, wind, etc.) affect foreign trade and alternative uses of land on which fossil fuels are presently mined?
2. What are the potentials of high voltage transmission?
3. What are the potentials of metal recycling?
4. What substitute sources or substitute economics can be envisioned for timber, forage, second homes, and recreation?
5. Examine environmental consequences of substituting recreational use for livestock use, timber harvest, and other economic uses.

Ref: Recreation and Tourism II-E-8 [F]

6. What are the physical, economic, and social values of regional water resources applied to alternative uses?

Ref: *Mineral and Energy, II-D-26 (#21)*

7. Develop a scenario concerning the future of environmental amenities-based communities and alternative transportation systems to serve them.

Ref: *Recreation and Tourism, II-E-6 (E,F)*

- a. Examine the various developmental consequences.

Refs: *Rural Residential Development, II-F-14 (#1.1); II-F-15 (#1.6)*

C. ECOLOGICAL PRINCIPLES AND CONSTRAINTS

In order that precise, defensible, and integrated management plans are designed for the maintenance of the natural environment, one must utilize both the current knowledge of ecosystem structure and function and the present and future biological constraints on management.

In examining ecosystem structure and function, one is looking at the biological-physical system within the Rocky Mountain Region. Any attempt to fractionate this resource must be artificial because of the integrated nature of ecosystems. With this in mind, there are four major characteristics of biological resources that should be of prime importance to regional planning and management. These characteristics are: (1) ecosystem stability, (2) ecosystem assimilative capacity, (3) biological diversity, and (4) ecosystem productivity. None of these characteristics are independent of the others; they all represent a somewhat different aspect of the resource.

Ecosystem Stability is viewed as the ability to (1) withstand external pressure without substantial alteration, or (2) recover rapidly following disturbance and to return to the original or a new dynamic equilibrium. The high level of self-maintenance found in stable, natural ecosystems minimizes social investments and maximizes future options.

Research questions which address ecosystem stability might include: (1) is it possible to build a ski resort in the Uinta Mountains without substantially altering the ecosystem? and (2) will the ski runs, once cleared of large vegetation, become stabilized with a new vegetative cover?

Assimilative Capacity is viewed as the filtering and buffering capacity of individual ecosystems in an area. This characteristic allows the ecosystem to reduce the effects of potential harmful or disruptive influences, thus enhancing system stability. For instance, do the piñon-juniper forests in the Rocky Mountain Region have a greater or lesser ability to cleanse the air than temperate deciduous forests?

Biological Diversity refers to the available diverse genetic material of the Region and is basic to maximizing management options. Genetic diversity within a population provides insurance for the continued existence of that population, as well as for other species directly or indirectly dependent upon it, despite environmental change. Is the Rocky Mountain Region one of the remaining strongholds for endangered species? What would be the impact on the genetic pool or consequences to man if these species become extinct?

Ecosystem Productivity is clearly a characteristic of interest to society, but it is also basic to maintaining biological diversity and the assimilative and stabilizing characteristics of ecosystems. This characteristic is typically divided into primary production and secondary production. Net primary production is the amount of autotrophs³ (primarily green plants), and represents that portion of plant community metabolism which creates organic matter which can be consumed by other organisms.

Net secondary production refers, in general, to the amount of organisms other than autotrophs. This production is essential for the maintenance of adequate populations which, for example, break down organic materials, sustain other organisms, contribute to the development of soil profiles, and inhibit the buildup of pathogenic populations.

A concept such as "carrying capacity" may be discussed within ecosystem productivity. This often-used term, "carrying capacity," is used to indicate the level of commodity and/or service production possible without destroying the ecosystem. In its simplest definition, carrying capacity refers to the productivity of an ecosystem. For example, alpine tundra cannot produce as much vegetation as deciduous forests. Because of this, alpine tundra cannot carry as many consumer organisms.

Carrying capacity varies with the durability of the ecosystem and the amount of investment capital available to adapt or maintain the system.

For instance, the natural productivity of desert land in the Rocky Mountain Region may be low. If man invests time, money, and energy to pump water into such desert country, the plant productivity and subsequent animal carrying capacity would be increased. With water being a major limiting factor to the carrying capacity in the Region, where can its "investment" yield the greatest productivity?

For ecological concepts such as carrying capacity, productivity, assimilative capacity, stability, and diversity to be useful in management plans and decision making, much research is yet needed.

³Plants capable of photosynthesis.

The research needs which follow are extremely pertinent:

INVENTORY

1. Develop methodologies to measure the several characteristics basic to biological resources (i.e., ecosystem stability, assimilative capacity, biological diversity, productivity).

*Refs: Timber and Forage, II-G-1 [i]
Water Resources, II-H-37 [i15]
Biological Resources, II-A-5 [i3]*

- a. Determine the bio-physical constraints (ecological constraints) on development of regional resources.

*Refs: Biological Resources, II-A-4 [V, #2]
Water Resources, II-H-6 [para. 2]*

2. Determine the meaning, validity and application of the concept of human carrying capacity to land use decision making.

*Refs: Recreation and Tourism, II-E-13 [E]
Rural Residential Development, II-F-15 [i1.3]*

- a. What are the variables in assessing and predicting the short- and long-term human carrying capacity in the Region?
- b. Study the human carrying capacity of areas and make strong recommendations restricting use where and when needed.

Ref: Biological Resources, II-A-5 [i5]

- c. How can visitors be acquainted with the carrying capacities of a recreation area?

3. What are the variables affecting rates of production?
4. What are the mechanisms of maintaining ecological stability on forested lands? This would include research on alternative pathways, carbon budgets, and other research relating to ecological stability.
5. What is the relationship between ecological diversity and esthetic values of forest lands?
6. Since climate changes with time: what are the implications of current changes in climate -- timberline, home heating requirements, snow cover and duration, flow in the Colorado River, etc.? What mountain stations are available with long-term records, for determination of current trends and comparison and contrasting with station records in the more densely inhabited areas?

7. Determine the cause and effect relationships of resource manipulation. Quantify use relationships in order to develop predictability of the effects of manipulation and the safe limits of manipulation for the ecosystems of the Region.

*Refs: Biological Resources, II-A-5 [i1]
Mineral and Energy, II-D-27 [i29, 30]*

RESPONSE TO IMPOSED CHANGE

1. Develop a standardized, region-wide ecosystem classification scheme (for continual synthesis and reinterpretation of impacts).

*Refs: Biological Resources, II-A-5 [i1]
Mineral and Energy, II-D-27 [i29 and 30]*

2. Evaluate management impacts on the biological resources in all classification units. This research should establish the relative effects of man-directed activities, or their combinations on major classification units. It should also identify threshold values, beyond which natural resource use should not proceed (e.g., establishment of regional carrying capacity or capacities).

Ref: Water Resources, II-H-49; II-H-3 [para. 5]

3. Establish a system of natural areas for ecological classification and research, and institute baseline measurements in each for comparative purposes.

Ref: Biological Resources, II-A-5 [i2]

D. INDUSTRY AND TECHNOLOGY

It has often been voiced that the indiscriminate use of technology has been a major cause of the destruction of our environment, and also that technology will solve all our environmental ills. Within this range of hopes and doubts, many questions can be raised over the use of technology and problems concerning industry in the Rocky Mountain Region. The participants of the Synthesis Workshop focused heavily on transportation systems and industrial plant location.

One of the most revolutionary technological advancements was the invention of the steam engine. With the pounding of the golden spike at Promotory Point, Utah, the Rockies were linked into a relatively speedy transportation system with the rest of the Nation. Mined ores could be sent over long distances with greater convenience and less expense. Settlement became inevitable. At the present point in the Region's development, questions need to be researched concerning the direction and desirability of various technological improvements and innovations in

transportation. Is there a need for a special type of transportation system in this sparsely populated Region?

Of great concern to many businesses is the location of their industrial plants. Court disputes have delayed and sometimes prohibited construction of plants in certain areas. Citizens have objected to the looks and location of many industries as well as to the pollutants they produce. In order to minimize the impact of plant location on the environment and the enormous losses which often accompany poor decisions, much thought and research must be directed towards this important land use.

The relevant inventory research needs concerning Industry and Technology follow:

INVENTORY

1. What is the impact of present transportation systems and utility corridors on resource use?

Ref: Rural Residential Development, II-F-14 [§1.1 b and d]

- a. Assess the environmental impact of slurry pipelines.
- b. What is the total energy investment in present and proposed transportation systems?

Ref: Rural Residential Development, II-F-17 [§4.5]

2. Evaluate case studies of communities and industrial complexes centered around major transportation developments in terms of their varying impacts on the environment. (Do mining towns centered around water transport vary from those where the transportation system is pack mule, train, or automobile?)
3. Evaluate case studies of small areas affected by development of logging roads, recreation roads, and trail systems as to their effect on the environment.
 - a. Determine the effects of trail systems and trail system use on conversion of wilderness areas into intensively used recreational areas, and pressure for new designation.
4. Determine the economic effect of public transportation access on land use.
5. Examine case histories of industrial and commercial plant location in the Rocky Mountain Region and accompanying environmental impacts.
 - a. Identify those types of locations which cause the least detrimental effects on the environment.
6. Assess the technological control devices that affect future development in the Rocky Mountain Region.

- a. Do sulfur scrubbers work sufficiently?
- b. Must the clean air in the Rocky Mountain Region be "significantly" degraded? Is 99% control of stack emission practical?
7. Assess the impact of industrial location on the economy of nearby towns. What is the relationship between increased/decreased industrial development and the increase/decrease in community tax base and local employment?

RESPONSE TO IMPOSED CHANGE

1. Determine methods of increasing the efficiency of transportation systems (vehicles, roads, utility corridors and lines).
2. Develop techniques for identifying and evaluating environmental impacts of transportation rights of ways and structures.
3. Is environmental protection and transportation efficiency planned for by the decision makers within the highway and transportation agencies (highway department, highway research board, etc.)? Determine where decision-making powers lie, the degree to which laws are complied, means of achieving funding changes, and new institutional arrangements, personnel policies, and state legislative reforms needed within these agencies.
4. Develop new methodology for industrial and commercial plant site locations (include methodology on choosing sites, as well as construction of the plant and blending the plant into the environment).

*Refs: Mineral and Energy, II-D-30 [§42]
Human Needs and Responses, II-B-7 [para. 2]*

- a. Specific attention should be paid to questions of legal constraints and land use planning.

Ref: Water Resources, II-H-36 [§13]

- b. Evaluate the economic costs of various methods of plant siting in relation to the environmental benefits.

5. Examine new industrial methods and equipment design.

- a. Develop evaluation procedures to assess the impacts of new technology on society and the environment.

Ref: Institutional Arrangements, II-C-5 [2.2 §3]; II-C-9 [para. 3]

6. Examine the feasibility of studying the Region's cap-

ability to assess its technology.

Ref: Mineral and Energy, II-D-28 (#33)

7. Conduct a feasibility study of mapping air particulate levels by Earth Resources Technological Satellites (ERTS) imagery.

DIRECTING CHANGE

1. Determine the regional, environmental, and socioeconomic consequences (through simulation modeling or other methods) of meeting the Region's current and prospective transportation requirements.

Ref: Rural Residential Development, II-F-17 (#4.5)

- a. Develop criteria and guidelines for use in planning, constructing, and managing these facilities.
2. Determine the environmental and socioeconomic consequences (through simulation modeling or other methods) on this Region of: (1) changes in the use of present and future transport systems due to such factors as gasoline shortages or increased costs of gasoline and (2) alternative modes of transportation and changes in transportation systems.
 - a. Determine effects of alternative transportation systems (including alternative locations) on: (1) long-range planning; (2) stream or lake sedimentation (erosion); (3) air quality; e.g., concentration of auto exhaust fumes in mountain canyons; (4) esthetics; e.g., location and configuration of rights of way and parking lots for automobiles, etc.; (5) noise pollution; e.g., automobiles, vs. monorail, vs. airplane; (6) plant and animal communities; e.g., soil compaction effects, trampling, interface with wildlife migration routes, etc.; (7) recreational values (quality of wilderness experience, etc.).
3. Examine the possibility and consequences of replacing movement of goods and people with the movement of information.
4. What would be the impact of transferring the regulation of transportation to a non-transportation agency such as a land use agency?
 - a. What would be the environmental effect of creating local/regional transportation districts in the States?
5. Determine the environmental impact of promoted and improved common carrier transport.

- a. Develop new modes of common and private vehicles; e.g., electric cars, trams.

- b. Research the potential benefits and opportunities of significantly increased common carrier travel.

E. DECISION-MAKING PROCESSES

Public participation in decision making is an important key in solving our potentially disruptive environmental problems. It is at the individual level that commitments to specified behavior are made. Knowledge of what various actions publics are pledged to support provides the decision maker with ideas to which his decisions should take cognizance of.

Often, the most difficult data to incorporate into short- and long-range decision making and planning is that concerning the variety of individuals' preferences. How can the decision-making process be designed to include public participation as an integral part of the process? How can it be made more responsive to changing needs and preferences?

This is a difficult question when it is realized that: (1) a single scale which could allow the comparison of the diverse preferences of widely differing social groups is lacking (presently, there is no common index by which the decision maker can balance the multiplicity of values); (2) social groups are not "socially neutral" -- that is each behaves in ways calculated to maximize its standing relative to the likely results of any given decision. Thus, they tend to minimize the importance of certain information and attempt, where possible, to pass costs on to others; (3) our social system is incredibly complex and presently almost impossible to model, consequently, many of the impacts of a given decision are unknown at the time the decision is made; (4) the chain of causes and effects within the social system are difficult to perceive; (5) there is an increasing interdependence of all things -- man, resources, and institutions with the result that even "small" matters which formerly responded to private decisions, now require political solutions; (6) there is a decreasing portion of "the total picture" which any one group is capable of perceiving; and (7) small well-organized groups can exercise considerable "veto power" within the political decision making context.⁴ Nonetheless, preferences must be communicated to decision makers, and the decision makers must perceive and utilize the preferences as revealed by the public.

In examining the research needs, it is of specific importance to understand how the decision-making process is functioning at the present time. The current points of

⁴See task force on Human Needs and Responses, page II-B-1.

decision, the decision makers, their effectiveness, and the causes of varying effectiveness must be examined.

Various tools and techniques are available to decision makers. Land use planning guides, overlay mapping, systems modeling, and remote sensing are but a few of such tools and techniques. Because of the number of questions in this area, "Management Tools and Techniques", has been broken into a sub-section.

Answers to the following research questions would facilitate an understanding of the decision-making processes and the effectiveness of the various management tools and techniques.

DECISION-MAKING PROCESSES -- GENERAL

INVENTORY

1. Identify those who make decisions about the Region from within and outside of the Region. At what point are the decisions made?

Refs: *Institutional Arrangements*, II-C-6 [3.1 #4]; II-C-10 [3.5]
Mineral and Energy, II-D-30 [#44]
Water resources, II-H-7 [para. 5]

- a. What information do they need?

Ref: *Recreation and Tourism*, II-E-13 [I]

- b. Who controls them? Who has the power?
- c. How do different decision makers respond to the same set of recommendations?
- d. Who makes decisions on research in the Region?

2. What research will lead to the enhancement of public choice by providing the decision makers with more systematic and comprehensive information concerning the state of the physical environment, knowledge of important social values held by the community, and the environmental and socioeconomic consequences of their policy choices?

Ref: *Institutional Arrangements*, II-C-1 [1.1]

- a. How can social values concerning land use decisions be better expressed and incorporated in land use decisions?

Refs: *Timber and Forage*, II-G-3 [ii]; II-G-4 [iii and iv]
Human Needs and Responses, II-B-4; II-B-2 [#5]
Recreation and Tourism, II-E-10 [H,L]

Institutional Arrangements, II-C-9 [3.3.3 b]; II-C-10

- b. Determine methods to accurately determine public opinion on resource management alternatives.

Ref: *Mineral and Energy*, II-D-30 [446]

- c. What information is needed for optimal decision making by various managers?

Refs: *Recreation and Tourism*, II-E-6 [G]; II-E-8 [C]; II-E-10 [F,G]
Timber and Forage, II-G-7 [Col. 2]

- d. How can technical information be delivered to decision makers so that it is comprehensible and unbiased?

Ref: *Recreation and Tourism*, II-E-8 [D]

- e. Study ways to incorporate ecological information in political decisions.

- f. What are the mechanisms for communicating research results to decision makers?

Refs: *Human Needs and Responses*, II-B-9 [B]
Recreation and Tourism, II-E-6 [H]

- g. How are research needs expressed to researchers? Is information relevant and understandable?

Refs: *Timber and Forage*, II-G-2 [Col. 2 #v]; II-G-3 [iv]

3. How effective are present methods of public participation (such as public hearings, petitioning, etc.)?

Refs: *Water Resources*, II-H-31 [#4]
Recreation and Tourism II-E-8 [E]

- a. How can they be improved?

- b. Does public participation increase the effectiveness of decisions?

- c. Is adequate notice and information about issues presented to the public to foster intelligent public participation?

4. How are voting behaviors affected? How well is the voting process working?

5. Identify regional experts, academic scholars, excellent industrial researchers, etc.

6. Is there danger in accepting goals and decisions made by research or academic elites? How can the danger be identified?

7. Evaluate how federal agencies make land use decisions and how funds are allocated.

Ref: Recreation and Tourism, II-E-7 [A]; II-E-8 [B]

- a. Administrative regions of federal agencies do not correspond to the Rocky Mountain Region's boundaries. Are decisions consequently fragmented? If so, what are the effects?

8. Are current decision-making arrangements adequate to preclude or control large negative externalities?

9. Analyze the political effectiveness of national versus regional environmental amenities organizations to determine their effectiveness in maintaining a high quality environment.

- a. Are the relatively new regional environmental groups more or less effective in maintaining environmental quality than the older extra-regional organizations?

10. Evaluate the space-costliness of the Region in terms of local decision maker's action in relation to open-option environments; e.g., investigate the social/psychological effect of low population density on the local decision maker's acceptance of extra-regional developers.

RESPONSE TO IMPOSED CHANGE

1. Determine effective methods of using economic evaluations in decision making in the management of publicly owned natural resources.

Ref: Human Needs and Responses, II-B-11 [para. 3,4]

2. What will be the impact of the racial, religious, or ethnic composition of immigrating populations on existing patterns of political participation; e.g., the effect on political and administrative decisions, on the budgetary priorities of public agencies, etc.
3. Develop a method to monitor the daily decisions on open-option lands in order to examine the consequences of the decisions.

DIRECTING CHANGE

1. Develop new methods for incorporating public opinion and public involvement into the decision-making process.

*Refs: Human Needs and Responses, II-B-9 [#4]
Institutional Arrangements, II-C-6 [2.4 #1]
Water Resources, II-H-29 [#2]*

2. Can decisions be made on a total system instead of on a fraction of it? Are they valid?

*Refs: Mineral and Energy, II-D-31 [#49]
Water Resources, II-H-12*

DECISION MAKING PROCESSES -- MANAGEMENT TOOLS AND TECHNIQUES

INVENTORY

1. Conduct case studies of management tools and techniques used within the Region to determine their effectiveness, appropriateness, and utility with emphasis on the acquisition of data; e.g., land use planning, zoning, legal restraints, trade-off analysis, capital investment, public purchase, tax structure, environmental impact statement, budgetary controls, public opinion/education, social pressure, industry, plant and road siting, ballot box.

*Refs: Timber and Forage, II-G-2 [viii]
Recreation and Tourism, II-E-13 [C,J,K]
Mineral and Energy, II-D-17 [#3]; II-D-31 [#48]*

- a. Is remote sensing being used effectively? Is remote sensing providing useful data to planners? What new data needed by planners could be acquired by remote sensing and computer mapping?

- b. Can better modeling be done in relation to computer-mapped data?

- c. How can the outputs of computer mapping be more easily conveyed to the public?

- d. Inventory and assess different types of land-management plans and planning.

2. Study the environmental impact statement at federal, state, and local levels. How effective is it in environmental improvement? What are its weaknesses? Who is resisting it, and why? Are staff, funds, and time frames adequate for its utilization? Is it being used as an end product itself, as a part of a process, as a public disclosure device, as a decision-making tool?

Ref: *Institutional Arrangements*, II-C-8 [3.3.1 #1 and 4]

RESPONSE TO IMPOSED CHANGE

1. What are the implications of research oriented to national problems?

- Explore the concept of funding projects whose scope is on small sub-regional components which in the aggregate may have a national impact.
- Conduct an environmental impact assessment of problem-oriented research on the Rocky Mountain Region.

2. What refinements and new additions to conventionally used methods of management can be developed? What might their impacts be?

Refs: *Timber and Forage*, II-G-3 [i, iii, v]; II-G-5 [ii, iii, v, vi]
Rural Residential Development, II-F-16 [2.6]; II-F-16 [3.2]; II-F-17 [3.4, 3.10]
Water Resources, II-H-36, II-H-39, II-H-43, II-H-44
Water Resources, II-H-15 [para. 2-4]

- What are the impacts of the technological systems on lower level management and what are management impacts on resource values?
- Develop improved management decision models which have the capability of accounting for non-economic values and multiple objective functions or goals.

Ref: *Institutional Arrangements*, II-C-5 [2.3 #1]

3. Develop methods of assembling data and using them for diagnosis of environmental and social problems (as is now done routinely in hospitals).

Refs: *Rural Residential Development*, II-F-17 [3.10]
Timber and Forage, II-G-2 [Col. 1, #ii]
Water Resources, II-H-43 [25]

4. Develop more effective, complete methodologies for assessing impacts on the environment.

Refs: *Institutional Arrangements*, II-C-5 [2.2 #1]; II-C-8 [3.3.1 #1]

- What are viable alternatives to environmental impact statements?

Ref: *Mineral and Energy*, II-D-32 [para. 1]

DIRECTING CHANGE

1. Determine how effective various management tools and techniques are for directing change. Are they capable of enforcement?

Refs: *Timber and Forage*, II-G-2 [Col. 1, #i]
Recreation and Tourism, II-E-8 [J,K]
Mineral and Energy, II-D-16 [45]

- Which are most effective in avoiding or minimizing adverse environmental consequences?

2. Determine long-range goals and objectives which can be stepped back in phase fashion to provide for five or so yearly goals and objectives with allowance made for contingency planning. What are the mechanisms for enforcing compliance with these goals?

Refs: *Mineral and Energy*, II-D-31 [48]

3. Develop modeling and other integrative, predictive tools for management.

Refs: *Mineral and Energy*, II-D-16 [45]; II-D-31 [48,50]
Timber and Forage, II-G-5 [3 iv, vi, ix, xi, xii]; II-G-8 [para. 3-6]
Human Needs and Responses, II-B-2 [para. 7]
Water Resources, II-H-41 [22]
Recreation and Tourism, II-E-8 [I]

- Identify the important variables in a systems approach, construction and use of ecosystem models, human systems models, resource response models, etc.

- How are feedback mechanisms built into research and models?

4. Develop management systems to allow for the integration of environmental impact statements into planning and implementation processes.

Ref: *Institutional Arrangements*, II-C-5 [2.2 #2]

F. INSTITUTIONAL ARRANGEMENTS

The Rocky Mountain Region has a high percentage of state and federally owned land. Thus, the decisions of federal agencies impact heavily on the Region. Each agency has a different purpose and alignment regarding the regional resources. Most often, the boundaries of jurisdiction of each agency are varied. Past history has shown that even within overlapping areas of jurisdiction, the agencies rarely communicated in depth to one another. Consequently, decisions affecting a given ecosystem are often

fragmented, even contradictory. There is also a lack of cooperation between various institutions in terms of sharing information and talent. This leads to an unnecessary duplication of work, with wasted time and money.

Inter-institutional exchanges of information and personnel might reduce duplication of effort and conflicts in goals and methods. A regional coalition of representatives from various institutions might be a useful vehicle for information transfer. Much of the above is concerned with the improvement of resource management institutions, but the concepts also apply to universities and legislative bodies.

In terms of economic institutions, one of the missing links between market arrangements and the environment is a way to integrate non-market factors with economic indicators. At present, there is no widely accepted method of attaching monetary value to environmental use and degradation. Thus, people's preferences relating to environmental quality can find little expression in the market system.

Until those costs which are now placed on society at large are accounted for in the market system, there is a need for enforceable laws to control the disruptions of natural ecological processes.

To address such problems, the research needs which follow have been divided into a general section on Institutional Arrangements with subsections on economic and legal arrangements.

INSTITUTIONAL ARRANGEMENTS -- GENERAL

INVENTORY

1. Determine the current level of cooperation between institutions; e.g., federal agencies such as Bureau of Land Management, Office of Management and Budget, and U.S. Forest Service, state agencies, universities, and local governments.

Refs: Institutional Arrangements, II-C-7 [3.2.2. #2]; II-C-8 [3.3.2 #6]

- a. Conduct case studies of agencies and institutions involved in environmental management of: a national forest, a Bureau of Land Management district, a national park, a highway project.

Refs: Water Resources, II-H-7

- b. Inventory and assess land management plans and planning by agency or institution and by method.

Refs: Institutional Arrangements II-C-8 [3.3.2 #1, 4, 5] Biological Resources, II-A-5 (#5)

- c. What problems inhibit planning and program coordination among local officials and state and federal land administrations?

2. Research the benefits and effects of existing regional coalitions including permanent organizations such as Rocky Mountain Center on the Environment, Federal Regional Councils, Federation of Rocky Mountain States, The Institute of Ecology's Committee on Future Environments, etc. and ad hoc groups such as the Environmental Advisory Council, Oil Shale Assessment Team, etc.

RESPONSE TO IMPOSED CHANGE

1. Develop mechanisms for improved cooperation and coordination between institutions, e.g., federal agencies such as: Bureau of Land Management, Office of Management and Budget, and U.S. Forest Service, state agencies, universities and local governments.

Refs: Mineral and Energy, II-D-35 [b] Water Resources, II-H-48 (#33)

2. Assess potential threats to the Region's environment. Identify alliances that form on different sides of the threats and also federal monies that go to support different alliances.

Ref: Mineral and Energy, II-D-17 [para. 6]

- a. Which issues might gain regional support?

3. Develop methods for the establishment of incentives for favorable environmental performance.

Ref: Mineral and Energy, II-D-28 (#34)

DIRECTING CHANGE

1. Develop plans for new regional coalitions and ad hoc organizations to fill a need which exists because of constraints in the existing institutions.

- a. Determine the feasibility, impact, and methods of creating a regional government.

- b. Analyze regional institutions to determine which could manage regional change brought on by pressures from in-migration, and resource development.

Refs: *Water Resources*, II-H-7 [para. 2]
Mineral and Energy, II-D-29 [#41]; II-D-30 [#42 and 45]
Institutional Arrangements, II-C-7 [3.2.1 #5]

- c. Determine the importance and effect of regional representatives being highly qualified resource managers appointed from an elective slate.
- d. Determine the kinds of issues where regional consensus decisions are necessary.
- e. Develop improved institutions to resolve conflicts between human values and goals.

2. Develop new regional institutions or new institutional linkages with the capability of doing broad based inter-disciplinary research.

Refs: *Institutional Arrangements*, II-C-6 [3.1 #1]
Human Needs and Responses, II-B-13 [#2]
Mineral and Energy, II-D-36 [para. 2]

- (1) What are possible ways of funding regional research; e.g., revenue sharing?

3. Develop institutional arrangements to improve communication of research results to decision makers, and research needs from decision makers to researchers; e.g., forums, release time, new budgetary arrangements for personnel exchanges, workshops.

Refs: *Human Needs and Responses*, II-B-4
Mineral and Energy, II-D-36 [para. 1]

- (1) Develop a structure whereby researchers, public and private administrators, legislators, and user groups can be brought together outside of their institutional roles to exchange ideas, examine issues, discuss administrative arrangements, determine research needs, and debate research findings. In other words, develop a regional "think tank."

Refs: *Human Needs and Responses*, II-B-13 [para. 3]
Recreation and Tourism, II-E-11,12 [A,B,C,D,E]
Timber and Forage, II-G-2 [vii]; II-G-3 [para. 7]
Institutional Arrangements, II-C-5 [2.3 #2]

4. Create a regional Research and Development council to determine goals for 1975-1980 and priorities and assessment methods.

Refs: *Institutional Arrangements*, II-C-9 [3.3.4 #1]
Mineral and Energy, II-D-36 [a]

5. Devise an indicator of the general well-being of a region -- similar to a Dow Jones Index -- where certain key data are assembled into an overall index number or a slightly more complex indicator, to be used as an early warning signal noting problems that are just surfacing, indicative of ongoing change.
6. Apply the Community Action Program research/action model developed over the last 10 years to a regional level (helping regional "powerless" people fight for their interest - urban coalition model).

7. Develop more interstate institutional arrangements.

Ref: *Institutional Arrangements*, II-C-7 [3.2.2 #3]

- a. How can states and counties most effectively act with real regional responsibility?

Refs: *Institutional Arrangements*, II-C-7 [3.2.1. #3];
 II-C-8 [3.31 #5]
Mineral and Energy, II-D-29 [#37]

- b. How can pressure most effectively be brought to bear on federal agencies to respond to regional problems?

- c. How can state agencies be given a regional rather than a federal focus?

- d. Determine the costs, benefits, and trade-offs of assigning institutional jurisdiction to resource management agencies by ecosystem boundaries, e.g., by watershed.

Refs: *Mineral and Energy*, II-D-35 [para. 2]
Institutional Arrangements, II-C-1 [Col. 2, para. 1]
Water Resources, II-H-30 [#3]

8. How can educational institutions be restructured to provide a more diverse "scientific reward system" than one based on publication activity?

9. Establish institutions which encourage the investigation of technological alternatives instead of merely improving present systems, e.g., inventions instead of modifications.

10. Would decentralized agencies be more effective in environmental management than the larger centralized state and federal agencies operating at present?

11. Determine consequences of alternative institutional and social arrangements on the resources of the Region. Determine the consequences of alternative choices of

resource management on institutions and decision-making processes.

*Refs: Institutional Arrangements, II-C-8 [3.3.1 #3]
Recreation and Tourism, II-E-13 [F,G,H]*

INSTITUTIONAL ARRANGEMENTS -- LEGAL

INVENTORY

1. Are national environmental laws and standards compatible with regional bio-physical characteristics?
2. Do federal environmental laws and standards conflict with those of the States in this Region? Is there conflict between one State's environmental laws/standards and another's?

Ref: Water Resources, II-H-35 [#11]

3. Complete a comparative analysis of individual rights in societies operating under differing constraints upon the use of their natural resources.
4. Inventory present western water laws, e.g., inventory the present legal commitments and status of water in the Colorado Basin.

*Refs: Rural Residential Development, II-F-17 [§'s 3.5, 3.6]; II-F-15 [#14]
Mineral and Energy, II-D-28 [#35]; II-D-29 [#39c]
Water Resources, II-H-20 [para. 5-8]*

5. Identify regional legal environmental experts.
6. Examine legal precedents for interstate cooperation (Tennessee Valley Authority, Regent Commissions).

Ref: Institutional Arrangements, II-C-8 [3.3.2, #6]

7. What are the legal constraints and existing land use controls on resource management?
8. What problems develop from the equitable distribution of the benefits of natural resources, especially when these resources come into short supply?

*Refs: Recreation and Tourism, II-E-8 [L,M]
Water Resources, II-H-31 [#5]*

RESPONSE TO IMPOSED CHANGE

1. Develop a system for incorporating local unique preferences into the laws. (Example: How can small

town horse trails be protected from highway construction?)

*Refs: Timber and Forage, II-G-4 [para. 4.5]
Institutional Arrangements, II-C-8 [3.3.1, #3]*

2. Develop criteria for future multiple use water laws for the Region.

- a. Revise the legal concept of beneficial use.
- b. Determine a legal hierarchy of demand.

Refs: Water Resources, II-H-29 [#1]; II-H-45

3. Determine if it is desirable to compensate owners of private property when environmental restrictions reduce the value or limit the use of such property.

Ref: Mineral and Energy, II-D-25 [#18]

4. What are the effects on capital availability of laws which require the absorption of all external costs of land subdivision by the developer -- by the public?

DIRECTING CHANGE

1. Design scenarios which assess the environmental impacts of alternate legal interpretations of the non-degradation proviso of the Clean Air Act.
2. Develop model standards for the Region that protect and enhance social and biological soundness.

INSTITUTIONAL ARRANGEMENTS -- ECONOMIC

INVENTORY

1. How does the size of a city in the Rocky Mountain Region affect the cost and effectiveness of services (school, water, police, fire protection, etc.) and the quality of life (crime indices, cultural opportunities, etc.)?
2. What is the economic value of the Rocky Mountain Region's environmental amenities (clean air, water, plentiful wildlife, etc.)?

*Refs: Recreation and Tourism, II-E-4 [C]; II-E-10 [D]
Water Resources, #5 II-4-31*

3. Determine whether the Rocky Mountain Region contains a higher percentage of service industries than the national average and analyze the reasons for this.

4. Determine the availability and cost of capital in the Rocky Mountain Region as compared to other regions and the Nation as a whole. If significant differences exist, determine the effect of the differences on this Region.

- a. What are the regional and national capital centers for investment?
- b. What effect does their location have on the Rocky Mountain Region?

5. Measure the regional and national consumption rates for various commodities such as: open space, clean air, timber, and energy fuels.

Ref: Mineral and Energy, II-D-27 (#28e)

6. Analyze the Region's flow of capital (quantity, origin of investments, etc.).

Ref: Timber and Forage, II-G-4 (v)

RESPONSE TO IMPOSED CHANGE

1. What are regional economic costs of neocolonial exploitation of the Rocky Mountain Region?
2. Determine the post-economic situation of the Rocky Mountain Region following increased local resource processing, extraction, and use. What local and regional economic benefits will be derived from such resource development?

Ref: Mineral and Energy, II-D-26 (#19g)

- a. Will there be shifts in distribution of income?
- b. Will short-term benefits of "boom town" development offset long-term social costs?

3. What is the economic cost of various degrees of population growth?

*Refs: Recreation and Tourism, II-E-4 (B); II-E-6 (I)
Institutional Arrangements, II-C-7 (3.2.1 #2)
Mineral and Energy, II-D-28 (#32)*

DIRECTING CHANGE

1. Determine the environmental impact of breaking up oligopolies.

2. What economic system can maintain itself with ecological integrity over the long run?

- a. What are the prerequisites of a sustainable long-run economy?

3. Determine practical methods of incorporating environmental and social "externalities" into market cost/benefit analysis.

Human Needs and Responses, II-B-6 (para. 4); II-B-12

Institutional Arrangements, II-C-7 (3.2.1 #2)

Rural Residential Development, II-F-17 (#3.1)

4. Identify the regional short- and long-term costs, benefits of varied levels of use, and trade-offs (social, environmental, economic, political) of potentially depletable renewable and non-renewable resources.

Ref: Recreation and Tourism, II-E-4 (D)

G. COMMUNICATION AND EDUCATION

As a community of people in the Rocky Mountain Region, we appear to be unable to communicate effectively with the decision makers of the Nation regarding the Region's problems, possible alternative solutions to these problems, and the consequences of each of the solutions. An abundance of information exists, but is not used. Research is not designed and/or integrated enough to address current and future problems. There is difficulty in defining the problems which exist, communicating these to researchers, conducting the needed research, and putting the results in a form useful to the public and decision makers.

By examining the problems which follow and developing solutions, the people of the Rocky Mountain Region may more effectively communicate their needs and desires to the Nation and effect changes in the direction they desire.

INVENTORY

1. Conduct research on methods to improve the communication of research needs from decision makers to researchers, and results of research from researchers to decision makers and the general public.

Ref: Human Needs and Responses, II-B-13 (#2)

- a. Determine what is the most usable form for these results?

2. How can television be used most effectively to instill an environmental awareness?

3. Develop regional resource atlases for differing audiences, including such data as: (1) natural biota; (2) agricultural lands; (3) mineral deposits; (4) watersheds; (5) population dispersions; (6) recreation sites; etc.

RESPONSE TO IMPOSED CHANGE

1. Develop methods for improved utilization of existing knowledge including the integration of research and improved application of research findings.

*Refs: Recreation and Tourism, II-E-11 [B]
Timber and Forage, II-C-2 [ii]
Human Needs and Responses, II-B-7 [a]; II-B-13 [1]*

2. Develop a retrieval system for putting multiple resource, product, and use information into usable form for sound resource planning and management programs.

- a. Develop methods of collecting dispersed data into a single regional document: How do we get the tremendous amount of information buried in volumes of industrial literature and academic archives into useful forms?

*Refs: Mineral and Energy, II-D-31 [47]
Institutional Arrangements, II-C-6 [3.1 42]*

3. How may improved methods of environmentally-oriented education be developed for the Rocky Mountain Region's citizens?

*Refs: Rural Residential Development, II-F-17 [4.4]
Recreation and Tourism, II-E-12 [F]*

- a. Improve methods of educating the Region's population on the effects of environmental management decisions and operations, and the significance of ecological constraints.

- b. Develop teaching units on the environment for primary and secondary schools.

4. Develop methods to supply interested citizens who are not environmental specialists or professionals with the kind, amount, and frequency of information required for them to know the state of their environment, to determine whether or not changes are required, and to make decisions as to what changes are desired.

5. Develop methods to supply legislators, citizens, and other decision makers with the kind, amount, and frequency of information required to evaluate existing policies and to develop new policies. This would include the information needed to identify the program and budgetary consequences of the policies being considered.

*Refs: Human Needs and Responses, II-B-i [para. 4, #1]
Recreation and Tourism, II-E-10 [J]
Institutional Arrangements, II-C-4 [2.1 #3]; II-C-5 [2.2., #4]; II-C-9 [3.3.4, #2, #3]*

6. Develop methods to supply interested citizens with the information that is required to evaluate the consequences of existing and proposed action by individuals, firms, government agencies, and to reach decisions about the desirability or undesirability of these consequences.

Refs: Institutional Arrangements, II-C-6 [2.4 #'s 1 and 2]; II-C-11 [para. 3]

7. Develop methods to permit incorporating into formal educational settings the kinds of information and the methods of using and processing information that are required for personal, agency, or group decision making.

*Refs: Timber and Forage, II-G-2 [ii]
Human Needs and Responses, II-B-2 [2]
Recreation and Tourism, II-E-10 [K]
Institutional Arrangements, II-C-10 [3.4.2]*

DIRECTING CHANGE

1. Develop a "hotline" for research in progress in the Region to enable researchers and research sponsors to get technical reports of work in progress or planned, in order to improve research which is in the planning state, avoid redundancy, and help researchers build on each other's work.

*Refs: Mineral and Energy, II-D-31 [47]
Timber and Forage, II-G-2 [vi]*

2. Develop an institutional arrangement that will enable environmentally concerned specialists and professionals to elevate their efforts to the production and communication of useful information about important environmental problems.

Ref: Human Needs and Responses, II-B-13 [2]

3. Develop an institute to produce information packages and communications systems required for more effective environmental education and communication.

4. What are the benefits/costs of creating regional planning and information handling center(s)?

a. Would communications be enhanced by centralizing data and/or data sources, by improving the analysis of data, by using modern data acquisition systems (such as remote sensing), or by having uniform data?

5. Develop a land-use planning policy manual for rural areas of the Rocky Mountain Region.

H. ALTERNATIVE FUTURES AND THEIR IMPLICATIONS

As a subject, "Alternative Futures and Implications" could rightly have been included in the section of "Decision-Making Processes: Management Tools and Techniques" since, in theory, planning processes are supposed to explore alternatives. However, RMER-Quest participants expressed a major concern for the Region's future and developing alternative futures as a researchable program in itself.

In order to direct change, it is necessary to have a regional set of goals. A society must have an image of the way it would like to be at some future time or it will proceed by increments to an undefined future state. Determination of the range of alternative futures is one important avenue towards providing a range of images from which society may choose its goals.

It is important for society to view a range of alternative futures in order that some consensus can be reached between various groups within society desiring different futures. The range of alternative futures is easier to describe than intermediate cases or an optimum case, if any such case can be defined. In fact, it is thought that "the" future cannot be predicted; future economic, social, political and psychological relationships cannot be predicted. Rather than predicting the future, scientists might posit alternative futures which seem plausible. Rather than develop THE PLAN for development of the future, scientists could develop a planning process which enables decision makers to respond to the changes in direction of the course of society and to the rates at which these changes occur. The society must have some time goals, because directing change requires not only knowing the direction in which to move society, but also the rate at which the movement should take place.

One parameter that is commonly used as a basis for alternative futures is environmental quality. At one end of the range is the environmental quality that results from no human use of the Region's resources. At the other end of the range is the minimum environmental quality that results from maximum and "messy" use of the resources with no

consideration of protecting water, air, land, and life. Within this wide range, each specific future defined has different implications for our natural resources, for ourselves. Some may hold open options for the future; some may foreclose options. Some alternatives may be sustainable for a longer period of time; some futures may exhibit greater stability and resilience. Others may offer a greater freedom of choice for the inhabitants and visitors who need undegraded resources for physical and spiritual sustenance; some futures may offer a freedom provided individuals by the comfort allowed through the development of the natural resources.

Research needs which help describe these alternatives and their implications are recommended below:

1. Describe a range of alternative futures for the Rocky Mountain Region and their respective implications.
2. What methods are being used for the "alternative futures" approach?
 - a. How well have these worked?
 - b. What are their individual problems?
 - c. How can they be improved?
 - d. How are future "uncertainties" identified? Is "sensitivity analysis" applicable?
 - e. How can all public sectors be involved most effectively?
3. How can the array of future alternatives and their implications most effectively be presented?
 - a. What tools are most effective for presenting the alternatives; e.g., resource maps, overlays, "scenario" presentations, models, benefit/cost analysis?
4. Define and develop criteria for maintaining open options.
 - a. Define what encompasses a foreclosure of options?
5. Identify key decisions about "alternative futures" which will actually be made and which could adversely affect the environment or could foreclose options for alternatives.
6. At what level of application is the "alternative futures" approach most appropriate; e.g., community, county, Region, Nation?

7. How can the "alternative futures" findings be implemented most effectively?
8. What are the effects of examining various futures by assessing the projections of probable future demand through a given time span (say the 50 years from 1975-2025) based on three or more (high, medium, and low) assumptions of national trends of population growth, economic growth, per capita income, new technology, resource capability, and other pertinent factors? Demand projections might be developed for:
 - a. Timber (by species group, size and quality. Class and evaluate the relative competitive position for major current and prospective uses).
 - b. Water (by area within the Region. Give attention to quality requirements, probable shifts in use).
 - c. Forage.
 - d. Recreation (by type, ranging from tourism through picnicking, hiking, camping, hunting, and fishing to skiing, etc. Assumptions may include a range of possibilities regarding wildlife population trends, changes in esthetics, etc.).
9. How are time scales determined over which the future is predicted; (e.g., are goals set for 5 years, 10 years, 50 years, 200 years)?
10. Study the implications of the changing patterns of land and resource use and its effects on future options:
 - a. What are the environmental implications of urbanization on open option lands?
 - b. What options are lost as we deplete the Rocky Mountain Region's resources?
 - c. Conduct case studies of changes in land/resource use to determine the direction of change.

APPENDICES

PART IV

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APPENDIX A

RMER-QUEST ORGANIZATION AND PROCESS

The origins of RMER-Quest are found in two different consortia of university researchers within the Rocky Mountain Region: The Eisenhower Consortium for Western Environmental Forestry Research and The Committee on Future Environments of the Rocky Mountain Region of The Institute of Ecology (TIE). The Eisenhower Consortium is composed of nine South Western universities and the U.S. Forest Service Forest and Range Experiment Station. COFE includes twenty-four universities and institutions in the Rocky Mountain Region within the United States and Canada. With the encouragement of the National Science Foundation (NSF) RANN Division, these two organizations merged and presented a joint proposal for RMER-Quest which was endorsed by both consortia. This was approved by NSF and the U.S. Forest Service in the spring of 1975. Sponsorship by the Environmental Protection Agency was received shortly afterwards.

This problem assessment was focused to (a) identify and evaluate the current and potential problems associated with the growing interaction of people and semi-primitive* environments in the Rocky Mountain area, and (b) determine and establish priorities for the research required to provide the necessary basis for environmentally sound resource management on public and private lands.

The RMER-Quest proposal included the design of a complex organizational structure, reflecting the interests of various groups in the project: the many universities, federal agencies, state governments, business and citizen groups within the Rocky Mountain Region. Responsibility for project management was given to a three-person directorate. This group was in turn responsible to a nine-person Planning Committee which included representation from:

Eisenhower Consortium
The Institute of Ecology's (TIE) Committee on Future Environments (COFE)
National Science Foundation
Environmental Protection Agency
U.S. Forest Service
Federation of Rocky Mountain States
Rocky Mountain Center on the Environment
Industry
University Researchers

This planning committee, meeting at two-month intervals, and sometimes more frequently, specified the strategy to be followed in the development of RMER-Quest. Together with the Directorate, they made fiscal and logistical decisions and frequently provided "course corrections".

The third important management element of the project was the Advisory Council. This consisted of Planning Committee members and an additional 26 individuals representing many other viewpoints, disciplines, and geographic areas within the Rocky Mountain Region. The Advisory Council convened as a formal group two times during the life cycle of the project, and provided frequent advice and feedback on the decisions of the Planning Committee by mail and telephone. Through their other organizational contacts, the Advisory Council members also served to provide two-way communications with other organizations and interest communities throughout the Region and Nation.

A Participatory Process

This review of the initial organizational structure of RMER-Quest indicates the importance given to the development of an open, participatory process. Instead of setting forth on a problem assessment or research effort involving a small staff, the Directorate and staff efforts were continuously directed to establishing and maintaining open, two-way communications with the interested researcher-user communities, who might be concerned with the project's development and findings.

Three crucial RMER-Quest activities benefited greatly from this effort to develop human resources which could assist in the work: (1) eight Task Force Reports were prepared very swiftly by over 150 volunteers throughout the Region; (2) the Task Force Reports, when completed, were reviewed and commented upon by an additional 150 volunteers; and (3) the task of developing ideas that synthesized RMER-Quest findings or bridged gaps that had not been fully explored was undertaken by 100 persons at a "synthesis workshop". Many of these individuals had not previously been involved in any of the preceding activities of RMER-Quest. In this manner the direct output of the project directly benefited from the efforts and enthusiasm of about 350 persons during the course of the year-long project.

*The term "semiprimitive" was changed to "open option" due to the connotations with the forest service's wilderness-primitive land classifications. Open option lands have come to be described as non-urban areas because of hazy distinctions.

The participatory process, which evolved from the Planning Committee's strategy, yielded another benefit. The continued two-way flow of communication with a large number of people from various interested groups gave greater assurance of producing well-documented, broadly-based research needs statements. It was anticipated that a report representing such a broad base of ideas would have a greater chance of being accepted and implemented.

The Task Forces

To accomplish the primary work of the project, namely, the identification of problems and research priorities, the Planning Committee determined on a division of labor. Seven or eight task forces would be appointed, each with a major focus. It was recognized that such disaggregation of the project's scope would result in some amount of unavoidable duplication as well as the need eventually to resynthesize results.

The overall charge of the project had therefore to be divided into complementary, but separable units, and the task of identifying the specific charge to each task force was presented in September 1973 to the Advisory Council at their first meeting. Several suggested divisions of labor were discussed vigorously during the Advisory Council meeting, which resulted in the determination to proceed with seven task forces. Five of these were grouped along resources and uses and the last two had a different focus as follows:

- 1) Mineral extraction, including energy production and distribution.
- 2) Recreational uses, including wildlife, tourism, wilderness, and esthetics.
- 3) Water resources and uses, including hydropower.
- 4) Timber and forage uses, including agriculture.
- 5) Residential and second home uses, including transportation.
- 6) Human needs and responses.
- 7) Institutional arrangements, including communications.

It is noteworthy that the development of the last two task groups represent a distinctive contribution of the Advisory Council, since the original RMER-Quest proposal had not specifically envisioned coverage of such subjects.

The Task Force leaders and members proceeded with their charge on a completely voluntary basis. Each task force was allotted \$4,500 for travel and support budgets, which was generally to cover meeting logistics, and duplicating, but not salary.

In the course of task group reviews, it became clear to the Directorate and planning committee that issues related to biological (ecosystem) resources within the Region were receiving insufficient attention in the seven task group reports. As a consequence, an eighth task group was mandated to focus attention on this topic.

Formal Reviews

In early March, the Draft Task Force Reports were sent to approximately 150 volunteer reviewers for scrutiny. About 80% responded to our request and provided further insight and improvements from their points of view. Top authorities from regional and national offices of Federal agencies, environmental organizations, and industry responded as well as state agencies, local citizen groups and professionals from specific fields (e.g., lawyers, academicians, doctors).

For each report, the responses were compiled and presented to the Planning Committee and the Task Force leaders before the Synthesis Workshop. These reviewers' comments were used considerably to guide the rewriting of the reports. The reviewers' comments also contributed in determining the major research recommendations of RMER-Quest.

The Synthesis Workshop

As noted previously, the Planning Committee recognized that a division of labor (the task force approach) could benefit the project, but also contained the potential difficulty of developing seven viewpoints within the project instead of one holistic integrated viewpoint.

A 3/5 day workshop was therefore designed by the Planning Committee in which to achieve the following goals:

1. To review the Task Force Reports and the reviewer comments and to identify important themes (or threads) between the reports and "gaps" not covered by the report.
2. To identify the major, significant research areas now and in the future in the Rocky Mountain Region.
3. To identify the most important research priorities that would emerge from considerations at this workshop.

About 40% of the participants had had no prior input into RMER-Quest whereas 60% had been deeply involved in the project to date. The workshop was conducted at the Grand Canyon on April 28-May 5, 1974, with 104 persons attending. The meeting used three different groupings to accomplish work:

1. Plenary meetings of the total workshop community (15% of the time).
2. Eight small groups of about 12 persons each (50% of the time).
3. Three larger groups comprised of the members of 2 or 3 small groups (35% of the time).

In retrospect, it seems that the workshop succeeded in accomplishing the first two objectives set for it (identification of Task Force "threads", themes, gaps, and problem areas of the Rocky Mountain Region). The goal of establishing research priorities was attempted but was not completed because of the lack of time.

Beyond the goal of integrating the immense amount of information within the task force volumes, many personal channels of communications were developed between the participants.

Wrap-up and Documentation

Following the workshop, the months of June, July, and August were devoted to documenting the findings of the RMER-Quest Synthesis Workshop, editing the final Task Force reports for publication, and obtaining feedback from the participants on the content and form of the project's report.

Development of Summary Chapter

Over a year's time RMER-Quest produced approximately 500 research needs. The Planning Committee felt that such a volume of equally weighted ideas was extremely difficult to assimilate. Consequently, it was decided to develop a method of selecting the most important research needs which would be presented in a summary chapter.

The approach selected was a type of content analysis. By a "voting" procedure the most often cited issues were determined as taken from the written documents: the revised Synthesis Report, the Final Task Force Reports, and the summary of the reviewers' comments. The total support for each topic was then determined by the following "voting" system:

- I. From the Synthesis Workshop Newsletters which documented all research needs:
 - A. All statements which were supported by groups A-B-C, (the sub-plenary breakdown composed of about 30 persons each) were given 10 points each. It was felt that to reach this level of support at least 10 individuals would have had to agree.
 - B. All statements which were supported by groups a-b-c-d-e-f-g-h, (a further breakdown of the group composed of about 15 persons each) were given 5 points each. In the smaller group level, it was decided that at least an average of 5 individuals would have had to agree.
 - C. Individual statements were given one point each.
- II. Task Force Reports (all points again based on the average number of individuals supporting it.)

A. Research needs marked critical were given 10 points each.

B. Research needs marked urgent were given 5 points each.

C. Research needs marked important were given 3 points each.

D. Research needs marked significant were given 1 point each.

III. Reviewers's Comments

A. Since these were tallied on an individual basis, they were given one point each.

Four of the Task Force Reports did not separate the research needs into the priority categories of critical, urgent, important or significant. However, the Task Force Reports on Recreation and Tourism had seven categories under which they had ranked the research needs in order of importance. A 25 % cut-off was used to place these research needs into the priority categories of critical, urgent, important and significant with the corresponding points. Within each of the remaining task force reports, certain research needs were given emphasis at the beginning of the report. Such statements were assigned 10 points each. Within the text of the report any research need stated once was assigned 3 points. It was felt that with as few research needs as were presented in these reports, none would have been supported by only a single person. When a research need was repeatedly stated in these reports it was assigned 5 points.

The research needs were then listed by subject area across the horizontal axis of a matrix. The source documents with tally breakdown formed the vertical axis. The total points received by each research need was then summed. To select approximately "20" major research needs a cutoff of "35" points was arbitrarily selected. This was a natural breaking point for the distribution of points received.

The "20" major research needs were rewritten and combined to provide clarity. They appear in this Final Report, Part IA, under Major Research Themes.

To prepare the introduction and set priority on these major themes, a special writing session was called during the end of October, 1974. Participants were selected to represent each of the organizational structures of RMER-Quest and maintain diversity of background. These individuals further refined the research theme statements and provided the sequence and form in which they are presented in Part I. RMER-Quest Staff conducted the final editing and preparation of the total document.

APPENDIX B

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